The world's most comprehensive encyclopedia of the military weapons of the 20th century

WAR MACHINE

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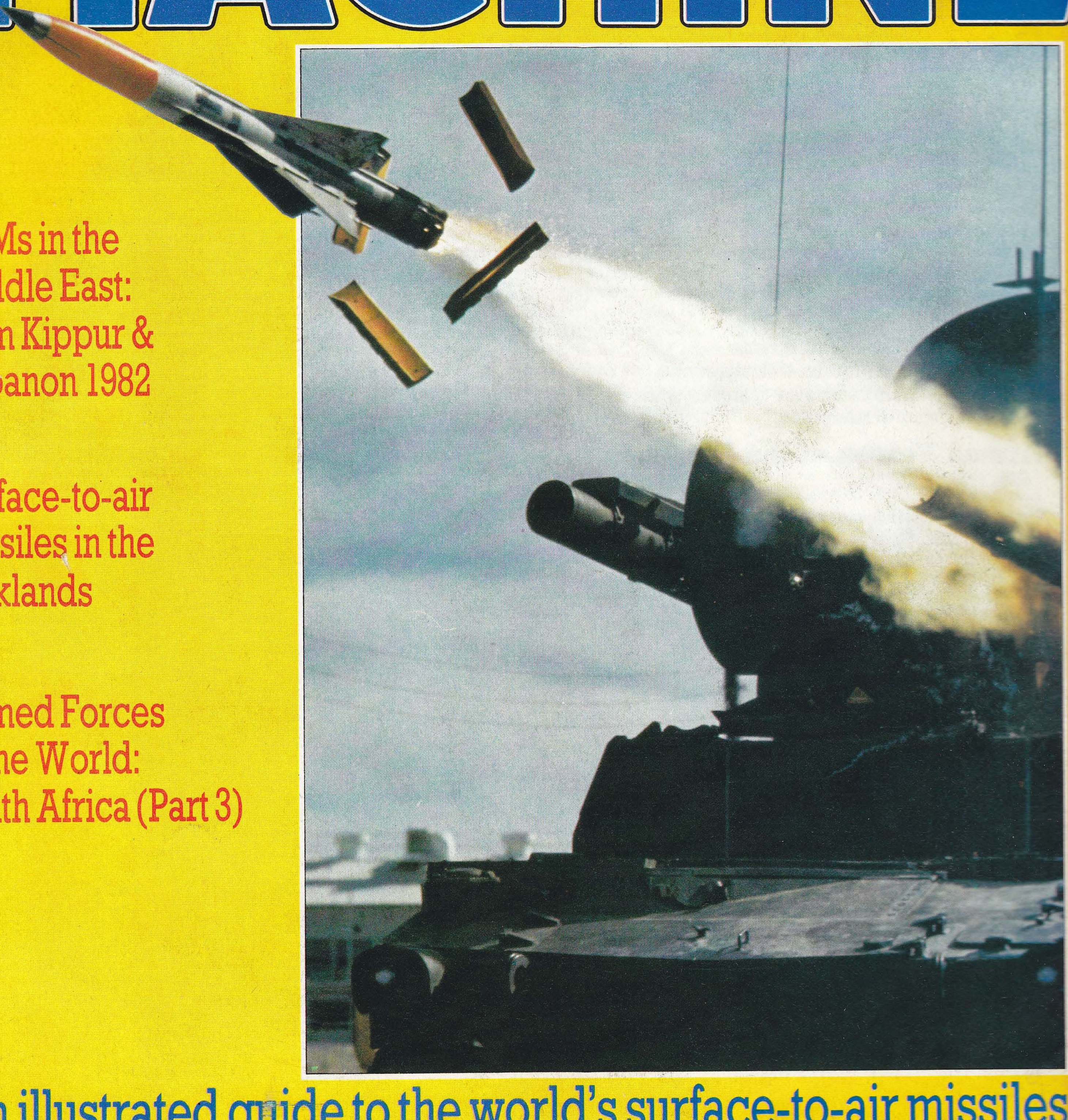

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Armed Forces of the World: South Africa (Part 3)

An illustrated guide to the world's surface-to-air missiles

WAR MACHINE

Volume 1 Issue 9

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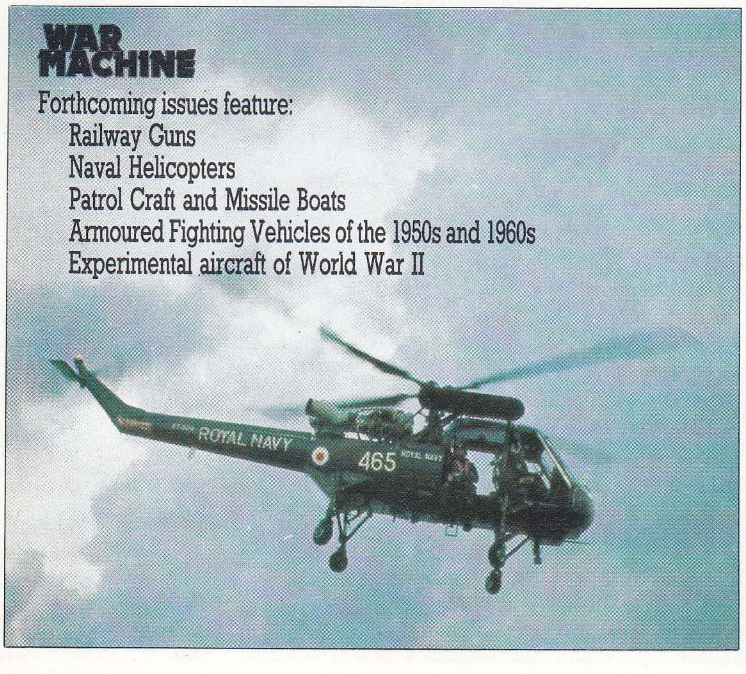

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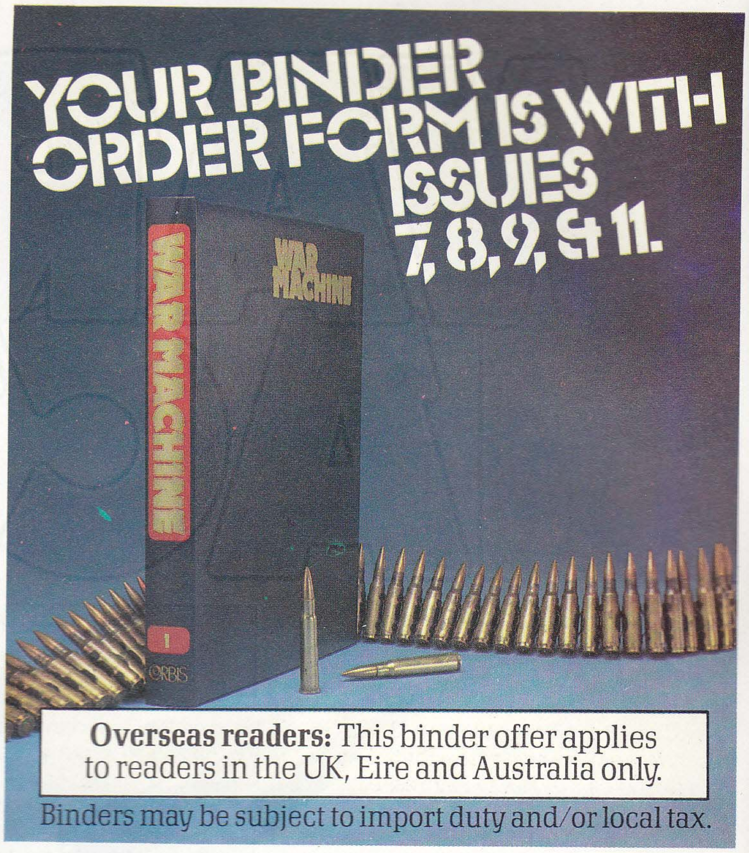

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Surface-to-air Missiles

Land forces are extremely vulnerable to air attack, and anti-aircraft systems are perhaps the single most important element in an army's equipment. Guns and surface-to-air missiles share this prime role, but the missiles are the more glamorous of the partnership.

A surface-to-air missile hitting a drone aircraft. The introduction of SAMs on a large scale has made air forces adopt new tactics to enable them to carry out their assigned mission. Most countries have a combination of gun and missile air defence systems, although some, for example the UK, rely only on missiles.

During World War II anti-aircraft guns were used on a large scale to provide defence against air attack for both armies in the field and fixed strategic targets such as ports, airfields, factories and other key centres. In the case of the Allies, low-level air defence was provided by weapons such as 20-mm cannon and the 40-mm gun, while high-level defence was provided by the British 94-mm (3.7-in) and US 90-mm (3.54-in) guns. As the war went on radar fire-control systems and proximity fuses were introduced by the Allies to increase the effectiveness of such weapons to a marked degree, especially against targets such as the V-1 flying bomb. The Germans faced even greater problems as Allied bombers took to flying higher and the number of weapons that could effectively engage them thus declined. From 1944 the Germans put considerable effort into the design of surface-to-air missiles (SAMs) but by the end of the war none of these had been deployed and much of their work was then taken over by the United States and the Soviet Union.

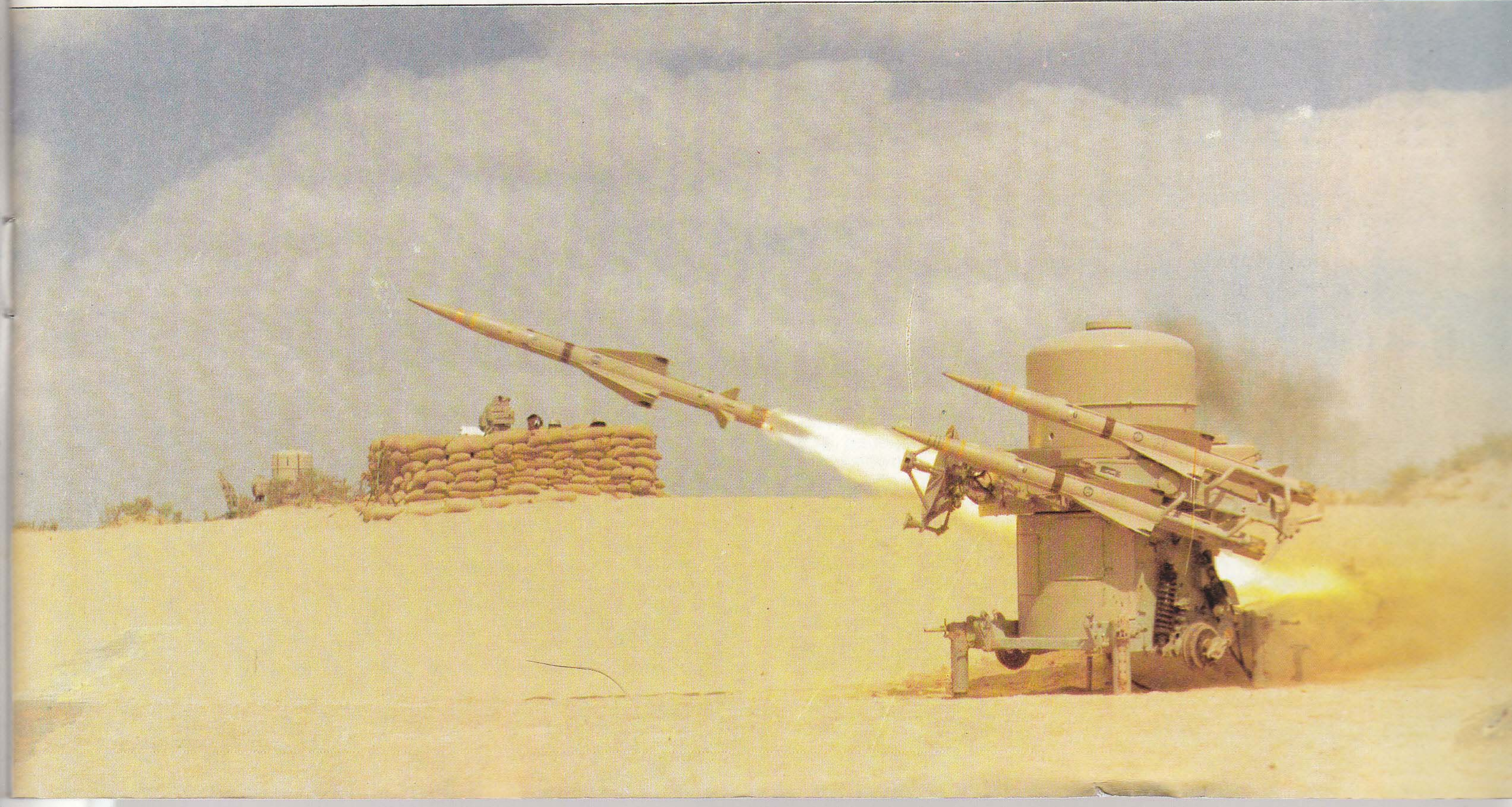
Flying at low level, aircraft must now run the gauntlet of both gun and missile systems, a combination which has proved to be most effective in the Middle East and Vietnam. Most armies today prefer a mix of guns and missiles although some, such as the British, rely on missiles alone (Blowpipe and Rapier). Some systems are highly mobile and are deployed well forward, for example the Roland 2 and Chaparral, while others are semi-mobile and need some preparation before they can be brought into action, for example the HAWK and towed Rapier.

In the West, the only SAM to be developed in recent years that can be used against both high- and low-flying aircraft is the US Patriot, which will replace the HAWK and the Nike-Hercules in US Army service. Development of this system started in 1965 but it was 1983 before the first battalion was formed, and since originally conceived the system has increased considerably in cost, and consequently it is not expected that many of the countries who now operate HAWK will be able to afford to replace it with Patriot.

Of all the countries in the world, the Soviet Union has by far put the most effort into the development and production of air-defence missile systems, many of which have been used operationally in the Middle East, Africa and the Far East. In some cases these systems have proved to be highly effective while in others, for example in the Lebanon in the summer of 1982, they have been totally ineffective. More often than not improper employment and poor operator training, rather than the design of the equipment, can be blamed.

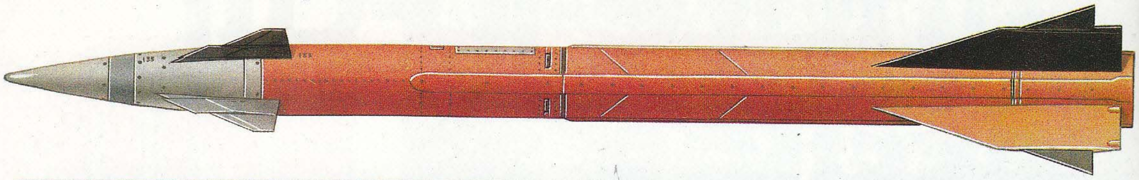
Recent years have also seen the employment of man-portable missiles, such as the SA-7 and Redeye, on a large scale, and these have proved to be highly effective in the hands of guerrilla and terrorist organizations, and they have not infrequently been used to shoot down civilian aircraft. More recent man-portable systems such as the Stinger and Blowpipe are even more effective.

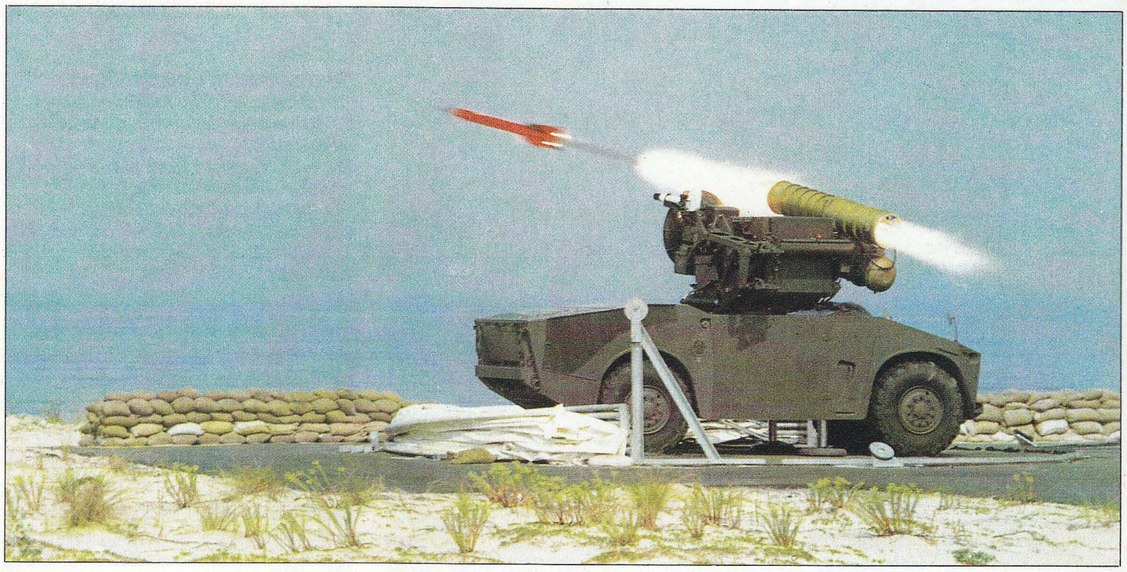
Mobile air defence weapons must be highly portable, tough and able to cope with climatic extremes. The BAe Dynamics Rapier system has proved itself in operation from the searing heat of Oman to the icy cold of the Falklands.



FRANCE

Crotale surface-to-air missile system





Crotale missile being launched during trials in France. The missile itself is manufactured by Engins Matra with the overall system and electronics being the responsibility of Thomson-CSF. It was originally developed to meet the requirements of South Africa but has since been adopted by many other countries. Further development has resulted in the Shahine, SICA which has been produced specifically for Saudi Arabia.

In the early 1960s the South African government placed a contract with the French company of Thomson-Houston, which later became Thomson-CSF, for the development of a mobile all-weather SAM system. This became known as the **Cactus**, Thomson-CSF being responsible for the overall system, radar and electronics, and Engins Matra for the **R.440** missile as it had considerable experience in the development and production of air-to-air missiles. The first batteries were delivered to South Africa in 1971 with final deliveries in 1973. Since then the **Crotale**, this being its French name, has been ordered by Chile, Egypt, Libya, Pakistan, Saudi Arabia and the United Arab Emirates. Further development of the Crotale has resulted on the Shahine, SICA which is in service with Saudi Arabia. There is also a naval version of the Crotale.

A typical Crotale battery consists of one acquisition and two or three firing units, each of the latter having four missiles in the ready-to-launch position. Both units are based on a fully armoured 4×4 chassis whose wheels are raised off the ground by hydraulic jacks when the vehicle in the operating position. An unusual feature of the vehicle is that it is electrically propelled.

The acquisition unit carries out target surveillance, identification and designation and is fitted with a large radar with a maximum detection range of about 18 km (11.2 miles). It also has a real-time digital computer, display consoles, data links and is capable of handling up to 12 targets simultaneously.

A target engagement takes place as follows. The acquisition unit first locates the aircraft and, if this is confirmed as hostile, allocates it to one of the firing units, target information being transmitted via a data link. The radar on the firing unit can track one target and guide two missiles at the same time, there being a slight gap in launching. The firing unit also has the command transmitter, infra-red gathering system, digital computer, digital data link and a TV/optical tracking system for use in an ECM environment. Once the four missiles have been launched new missiles in the transport/launching containers have to be loaded with the aid of a crane. Four missiles can be loaded in about two minutes by a well trained crew.

The R.440 missile is 2.89 m (9 ft 5.75 in) long, 15.0 cm (5.9 in) in diameter and 54.0 cm (21.25 in) in span, and weighs 85 kg (187 lb) of which 15 kg (33 lb) is accounted for by the HE warhead, which is of the fragmentation type to cause as much damage to the target as possible. The warhead is detonated by a proximity fuse which is not armed until after the missile is launched. The single-stage solid-propellant rocket motor gives the missile a top speed of about Mach 2.3. The effective range of the system depends on the speed of the target, but against an aircraft flying at a speed of Mach 1.2 a maximum range of 8500 m (9,295 yards) can be achieved with a maximum altitude of 3000 m (9,845 ft). Against slower aircraft and helicopters, the range is significantly greater.

The Crotale is normally used (for example by South Africa, Saudi Arabia and the French air force) for the defence of air bases and other strategic targets. Once halted, the Crotale/Cactus system takes about five minutes to become fully operational. Information from the acquisition unit can be passed to the firing unit by cable (maximum length of 800 m/875 yards) or a data link (maximum range 3000 m/3,280 yards).

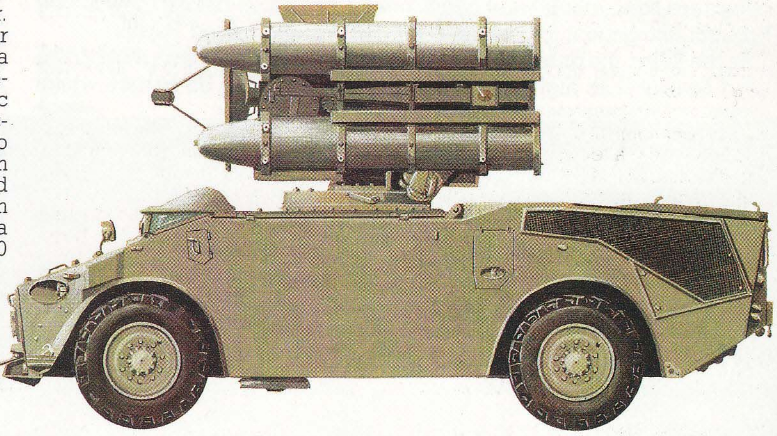
Specification

Matra R.440

Dimensions: length 2.89 m (9 ft 5 in); diameter 15 cm (5.9 in); span 54 cm (21.25 in)

Launch weight: 85 kg (187.4 lb)

Performance: speed Mach 2.3; maximum ceiling 3000 m (9842 ft); maximum range 12000 m (6.8 miles) against a 2000 m/sec (450 mph) target



Each Crotale launcher has four missiles. Three firing units are coupled to one acquisition unit to form a battery.

FRANCE

Shahine, SICA surface-to-air missile system

The **Shahine, SICA** low-altitude SAM system was developed from 1975 specifically to meet the requirements of Saudi Arabia and is a logical development of the earlier Crotale. Prime contractor is the Electronics Systems Division of Thomson-CSF, which is responsible for the radars, electronics and systems integration; Engins Matra is responsible for the missiles. Following successful trials with prototype systems, production started in 1979, the first systems being delivered to Saudi Arabia in 1982 and final deliveries being made in 1983. A total of 36 systems were delivered as were 53 AMX-30 DCA self-propelled 30-mm anti-aircraft guns to provide close in protection, especially when missiles are being reloaded.

The Shahine consists of a firing unit and an acquisition unit, each mounted on a modified AMX-30 MBT chassis which offers complete armour protection for the crew and electronics inside the vehicle as well as having much improved cross-country performance than the original Crotale wheeled system.

The acquisition unit has a large pulse-Doppler surveillance radar with a range of some 18 km (11.2 miles) with a digital receiver for the MTI (moving target indication) function. The automatic information processing and threat evaluation system allows up to 40 targets to be registered on the computer and no less than 18 actual targets to be handled. One acquisition unit can control up to four firing units.

The firing unit has six missiles in the ready-to-launch position (the basic Crotale has four); once these missiles have been launched replacement missiles in travelling/launch containers are loaded from a vehicle with the aid of a crane. Between the missile is a triple-channel fire-control radar that can simultaneously guide two missiles to a target. The radar tracks the missile and sends out guidance commands, acquisition of the missile during the early part of the flight being via an infra-red receiver sensitive to the wavelength of the missile exhaust. Another feature of this system is that a

Shahine, SICA surface-to-air missile system (continued)

TV system is integrated into the turret and this assumes target- and missile-tracking functions and also ensures a full back-up mode in case of enemy jamming.

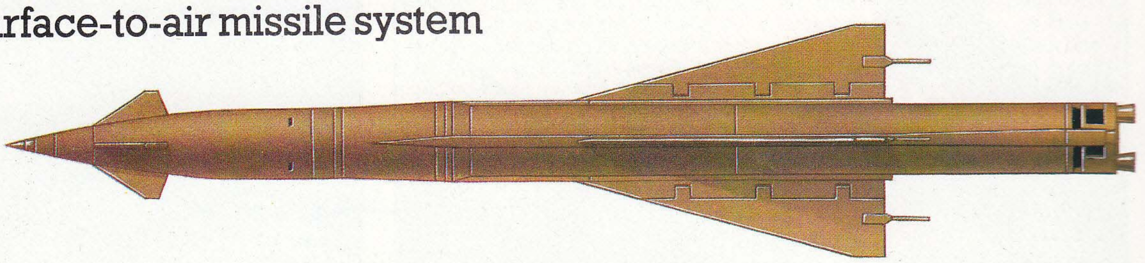
The missile used by the Shahine is the **Matra R.460**, a longer and heavier version of the Matra R.440 used in the Crotale system, its SNPE double-stage rocket motor giving a burn of 4.5 seconds (compared with 2.5 seconds in the Crotale system) to produce a maximum speed of about Mach 2.

A major advantage of the Shahine over the original Crotale is that the firing units and acquisition unit can deploy over a much wider area as they do not have to stop and be coupled together by cables before target engagement. This is possible as the Shahine units are fitted with an automatic data transmission and reciprocal microwave system. This, coupled with the fact the missiles and radars have a longer range, makes the Shahine much more effective than the Crotale.

Specification
Matra R.460
Dimensions: length 3.15 m (10 ft 4 in); diameter 15.6 cm (6.14 in); span 59.0 cm (23.23 in)
Launch weight: 100 kg (220 lb)
Performance: maximum ceiling 6100 m (19,685 ft); maximum range 10000 to 13500 m (12,030 to 13,125 yards)

FRANCE/WEST GERMANY

Roland surface-to-air missile system



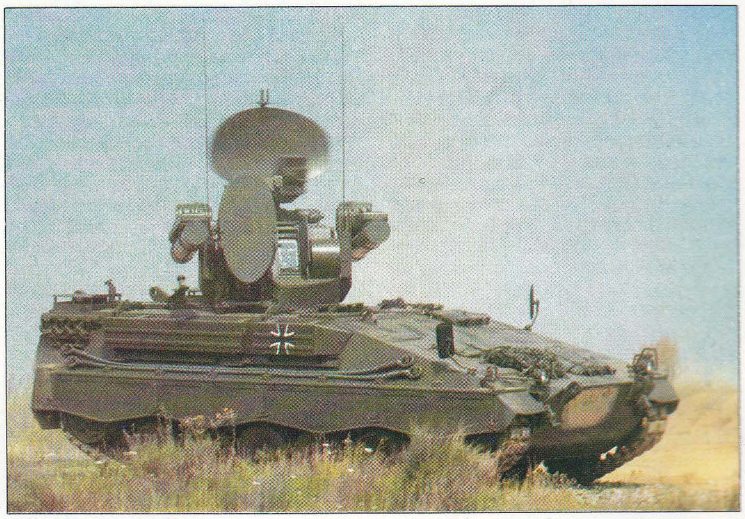
In the early 1960s Aérospatiale of France and Messerschmitt-Bölkow-Blohm of West Germany, working as Euromissile, began the development of a mobile low-altitude surface-to-air missile system which eventually became known as the **Roland**. France was responsible for the Roland clear-weather version while West Germany was design leader for the **Roland 2** all-weather version. As the Roland 2 is the current production model the description relates to this model. In the West German army Roland is based on the chassis of the Marder MICV while France uses an AMX-30 MBT chassis and the United States the M109 self-propelled howitzer chassis.

A typical target engagement of the Roland 2 takes place as follows. The pulse-Doppler radar, mounted on top of the turret rotating at 60 rpm, detects aircraft and helicopters at a range of between 15 and 18 km (9.3 and 11.2 miles). The target is then interrogated by the vehicle's own IFF system and, if confirmed as hostile, acquired and tracked. In normal engagements tracking is carried out by the tracking radar mounted on the forward part of the turret, but if enemy countermeasures are active an optical sight can also be used. In the radar mode the tracking radar has two channels, one of which tracks the target and the other the missile. The radar is slaved to follow the target by misalignment. Once a missile has been launched an infrared localizer on the antenna of the tracking radar is used to capture the missile between 500 and 700 m (545 and 765 yards) after launch as by this time the missile has entered the pencil of the tracking radar. Missile deviation is calculated from the angular deviation between target/antenna and antenna/missile, this information being supplied to the on-board computer which calculates the required guidance commands which are then passed onto the missile via a radio command link. The missile receives the commands which are then converted into jet-deflection orders. With Roland it is possible for the operator to switch from the optical to the radar mode after the missile has been launched. The optical method is used whenever possible as it is more accurate, especially in a ECM environment.

The two-stage solid-propellant missile is 2.40 m (7 ft 10.5 in) long, with span and diameter of 50.0 and 16.0 cm (19.7 and 6.3 in respectively), and has a cruising speed of about Mach 1.6. Launch weight is 63 kg (139 lb), and the missile is provided with a high explosive warhead that is detonated either by impact or an electromagnetic (radar-type) proximity fuse.

In the case of the Marder and AMX-30 chassis versions of Roland, two missiles are carried in the ready-to-launch position, an additional eight missiles being carried inside the vehicle for automatic loading from two rotary-type magazines each holding four rounds.

In addition to being used by France and West Germany, the Roland is also used by Argentina (shelter version), Brazil (four only on Marder chassis), and the United States (27 systems only, built in the United States by Boeing and Hughes). The type has also been ordered by Iraq, Nigeria, Venezuela and Jordan via Iraq. There is also a shelter-mounted version of Roland which can be carried on a 6×6 chassis or used in the static defence role.

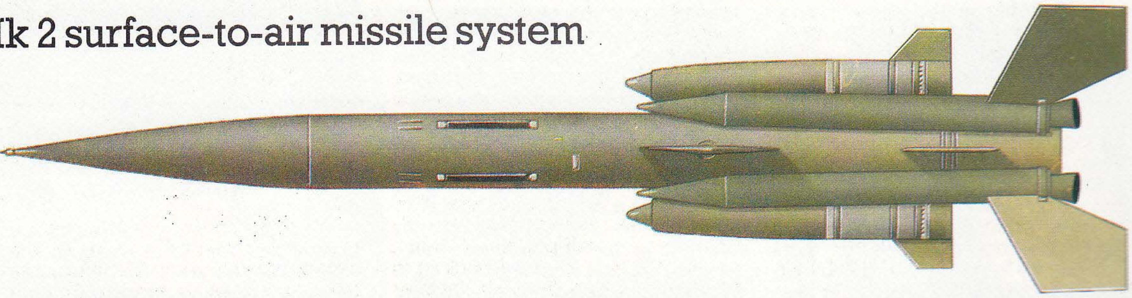


A West German army Roland SAM system, on Thyssen Henschel Marder chassis with two missiles in ready-to-launch position and eight missiles in reserve.

Specification
Roland 2
Dimensions: length 2.4 m (7 ft 10½ in); diameter 16 cm (6.3 in); span 50 cm (19.7 in)
Launch weight: 63 kg (139 lb)
Performance: speed Mach 1.5; range 6000 m (3.73 miles); radar detection range 16 km (9.95 miles); minimum interception range about 500 m (1640 ft); minimum interception height under 20 m (65.6 ft)

UK

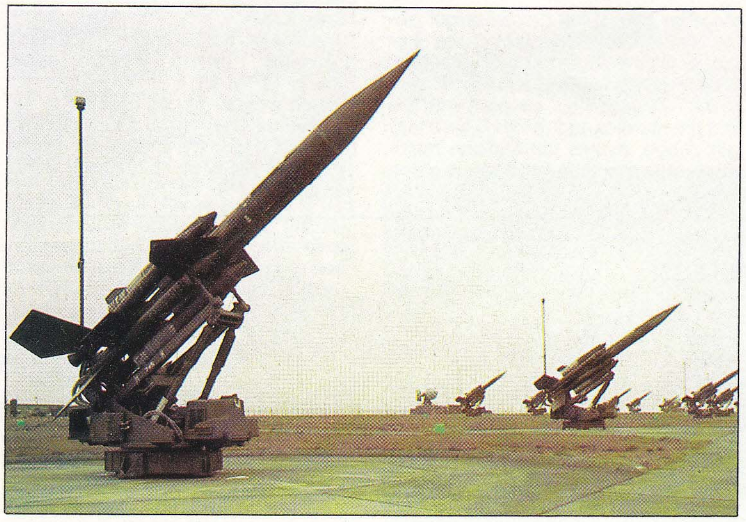
Bloodhound Mk 2 surface-to-air missile system



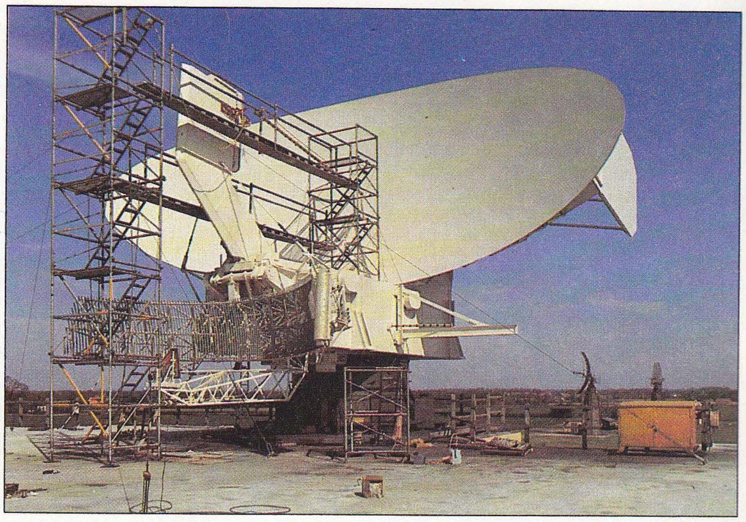
The original **Bloodhound Mk 1** SAM system was developed from the late 1940s (to meet the requirements of the Royal Air Force) by the Bristol Aeroplane company (now British Aerospace Dynamics) and Ferranti, the first units becoming operational in 1958. Further development resulted in the much more effective **Bloodhound Mk 2**, which entered service in 1964. This was deployed by the RAF in the United Kingdom, West Germany and Singapore but by early 1983 those in West Germany had been redeployed to the United Kingdom and those in Singapore had been handed over to the Singapore Air Defence Command. The weapon is also used by Switzerland under the designation **BL-84** and was also used by Sweden as the **RB 68**, but these were recently withdrawn from service. The British Army had a very similar missile system called the **Thunderbird**, but this has now been withdrawn from service without replacement, so leaving the army without any high-level air-defence system.

A typical Bloodhound missile section consists of four missiles on their individual launchers, target illuminating radar (TIR) and a launch control post (LCP). Two TIRs were developed, the air-transportable Ferranti Firelight and the semitransportable Ferranti Scorpion, the latter having a much longer range.

A Bloodhound target engagement takes place as follows. A target is first detected by surveillance radar, which may be part of the Bloodhound system or part of an overall air-defence system which would decide which particular weapon system would engage the target. Basic target information is then supplied to the TIR, which searches for the target, then tracks and illuminates it. At the same time the TIR



Bloodhound SAMs on their launchers at an RAF base. All these missiles have now been withdrawn from West Germany and concentrated along the east coast of England; no official announcement has so far been made concerning their replacement.



The RAF also uses the Marconi Type 82 series radar for surveillance purposes with the Bloodhound SAM. In the background is a Plessey HF 200 height-finding radar. The Bloodhound is also used by Switzerland and Singapore.

transmits this information to the launch control post. A computer in the latter then determines the optimum conditions for target engagement. When the target is within range a missile is launched, the receiver in the nose of the missile detecting and homing onto radiation reflected by the target. The warhead of the missile, which is in fact well to the rear of the nose, is high explosive and fitted with a proximity fuse developed by EMI Electronics.

The missile itself is launched by four solid-propellant boosters, which are mounted externally to take the missile to supersonic speed when the two Thor ramjets take over and the boosters fall away. The ramjets are mounted above and below the missile and give the missile an exceptional range of some 80 km (50 miles) and a maximum speed of some 3860 km/h (2,400 mph). The control surfaces of the missile consist of two moving wings to provide the necessary manoeuvres and cruciform fixed tailplanes to provide pitch stability. The missile manoeuvres by means of twist and steer in the same way as a bird in flight: the wings are moved differentially so as to roll the missile into the vector direction in which the manoeuvre is required, and then moved in concert to pitch the missile in that direction to complete the manoeuvre.

For ease of repair, most of the guidance system is on printed circuit cards, which enables replacement of faulty cards to be carried out very quickly, so returning the missile to an operational status without undue delay.

Specification

Bloodhound Mk 2

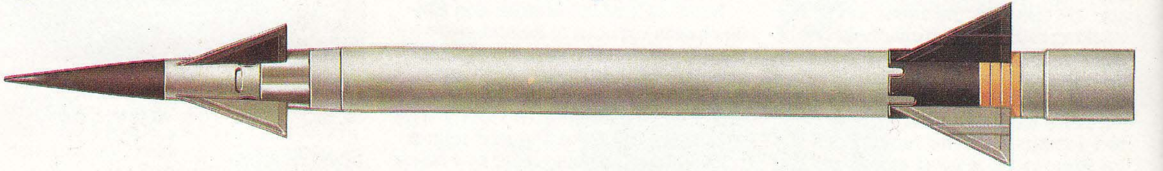
Dimensions: length 7.75 m (25 ft 5 in); diameter 54.6 cm (21.5 in); wing span 2.83 m (9 ft 3½ in)

Weight: 2300 kg (5,070 lb)

Performance: operating altitude 100 to 23010 m (325 to 75,500 ft); range over 80 km (50 miles)

UK

Blowpipe man-portable surface-to-air missile system



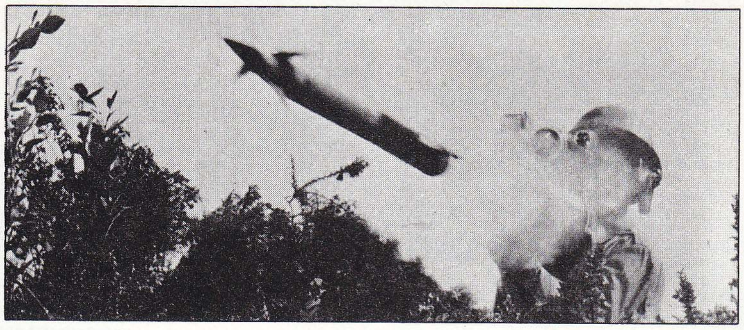
The **Blowpipe** missile was developed by the Missile Systems Division of Short Brothers to meet a British army requirement for a man-portable SAM missile system that could shoot down an attacking aircraft before it released its weapons. Other man-portable missiles, such as the American Stinger and the Soviet SA-7 home onto the exhaust of the attacking aircraft and can often only engage the attackers after they have released their weapons.

The Blowpipe system consists of two main components: the missile within its launching canister and the aiming unit. In the missile itself the forward part contains the guidance equipment, the HE warhead is in the centre and the rear part houses the rocket motors. There are four delta-shaped aerofoils on the nose for aerodynamic control and four at the tail to provide ballistic stability. The nose section of the missile is free to rotate independently of the main body, it being attached to the latter by a low-friction bearing. The missile is factory-sealed in a lightweight container which acts as a recoilless launcher. The container houses the firing sequence unit, thermal battery to power the aiming unit, guidance aerials and electrical connections. When the missile gyro is fired the front cap of the container is blown off by gas pressure while the laminated rear closure is ejected at launch.

The aiming unit is a self-contained firing and control pack with a pistol grip on the right side. The aiming unit contains a radio transmitter, auto-gathering device, monocular sight and, if required an interrogator (IFF) system. The controls include a trigger, thumb-controlled joystick and switches for fuse option, auto-gather and guidance command frequency change.

Before use the aiming unit is clipped onto the canister containing the missile. The target is obtained visually in the monocular sight, which has a graticule to assist the operator in both range estimation and allowance for cross winds. The safety catch is then released and the trigger squeezed. The latter activates a generator which supplies firing current to the thermal batteries in the missile and canister. The missile is launched from the canister by a first-stage motor. Once the Blowpipe is a safe distance from the operator the second-stage motor ignites to accelerate the missile to supersonic (Mach 1.5) speed, the missile then cruising as a fully controlled dart. The Blowpipe is then automatically gathered into the centre of the operator's field of vision. He then guides the weapon onto the target by radio command produced by movements of the thumb-controlled joystick. The high explosive warhead is detonated by impact or a proximity fuse. Once the target has been destroyed the operator unclips the empty canister and replaces it with a fresh unit; he is then ready to commence another target engagement.

In the British Army Blowpipes are operated by the Royal Artillery. The weapon is also used by eight other countries including Argentina, Canada, Oman and Thailand. During the Falklands campaign of 1982 the Blowpipe is credited with shooting down at least nine Argentinian aircraft, with a further two claimed as probables.



A Shorts Blowpipe man-portable missile leaves its launcher tube. Unlike the Redeye, the Blowpipe does not home onto the exhaust of the attacking aircraft and is therefore able to engage the target before it releases its weapons.

Specification

Blowpipe

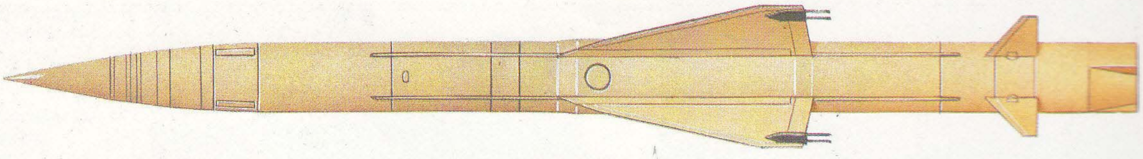
Dimensions: length of missile 1.39 m (4 ft 4.7 in); length of canister 1.40 m (4 ft 7.1 in); diameter of missile 7.60 cm (3 in); span 27.5 cm (10.8 in)

Weights: complete system 21.9 kg (48.3 lb); missile and canister 13 kg (28.7 lb); missile 11 kg (24.5 lb)

Performance: effective ceiling 2000 m (6,560 ft); effective range about 3 to 4 km (1.86 to 2.5 miles)

UK

Rapier surface-to-air missile system



The **Rapier** low-level air defence missile system was developed by the British Aircraft Corporation (now British Aerospace) to meet the requirements of the British army and Royal Air Force for a mobile SAM system to replace the 40-mm Bofors guns then in service. Development started in the early 1960s, and the first production units were completed in 1971. In addition to being used by the United Kingdom, the Rapier has also been ordered by Abu Dhabi, Australia, Brunei, Iran, Oman, Qatar, Singapore, Switzerland, Turkey, Zambia and the United States. In the last case the weapon is used to protect USAF bases in the UK.

The basic clear-weather Rapier system consists of a fire unit, optical tracker and a generator. The former has four missiles in the ready-to-launch position, survillance radar, IFF sytem, command transmitter and computer. The system is transported into action by two long wheelbase Land Rovers, one towing the missile launcher with its four missiles, generator, tracker and some reload missiles, and the second a trailer carrying additional missiles.

A typical target engagement takes place as follows. The target is first detected by the surveillance radar mounted on top of the launcher and is then automatically interrogated by the IFF system. If the target is friendly no action is taken but if hostile the tracker operator is alerted. The operator then acquires the target in his optical sight and tracks it using a joystick control. The computer informs the operator when the target is within range, and a Rapier missile is then launched. Once the missile has been launched the operator continues to track the target using the joystick. A TV camera in the tracker, collimated to the tracking sight, watches the flares mounted in the tail of the missile and so measures a deviation from the sightline. The measurement is then fed to the computer which issues orders to the command transmitter for transmission to the missile. The missile itself is fitted with a high explosive warhead with an impact fuse. Once the four missiles have been launched new missiles can be quickly loaded by hand.

To give the system an all-weather capability Marconi Space and Defence Systems have developed the trailer-mounted DN181 Blindfire radar which can also be towed by a Land Rover or similar vehicle. In the **Blindfire Rapier** system the operator does not have to track the missile, this being fully automatic.

Early in 1983 the British army took delivery of the first of 62 **Tracked Rapier** systems. This was originally developed to meet the requirements of the Imperial Iranian Army but this contract was cancelled with the fall of the Shah. The Tracked Rapier consists of a modified M548 tracked cargo chassis, which itself is a member of the M113 family of vehicles, with a fully armoured cab. On the rear is a Rapier launcher with eight missiles (four on each side) in the ready-to-launch position, with additional missiles carried in reserve. The optical tracker is located in the cab and projects through the roof. In the future the Royal Artillery will have a mixture of towed and tracked Rapier systems.

At the 1983 Paris Air Show British Aerospace announced the **Rapier Laserfire**. This consists of a pallet which can be mounted on a variety of vehicles and has a surveillance radar, automatic laser tracker, crew cabin with system controls and displays, computer and other electronics, four ready-to-launch missiles, and a command link. The target is detected by the surveillance radar as in the basic Rapier system, but if deemed to be hostile the target is then acquired by the automatic laser tracker, which locks onto the target to provide the laser line of sight for the command to line of sight system. All the operator has to do is to fire when the indicators state that the target is in range. The Rapier missile is then commanded to fly along the laser sight line to impact with the target.

Rapier was first used operationally by Iran against Iraq during the 1970s, in the still-continuing Gulf War, and by the Royal Artillery in the Falklands campaign of 1982, when it is credited with shooting down some 20 aircraft.

Specification

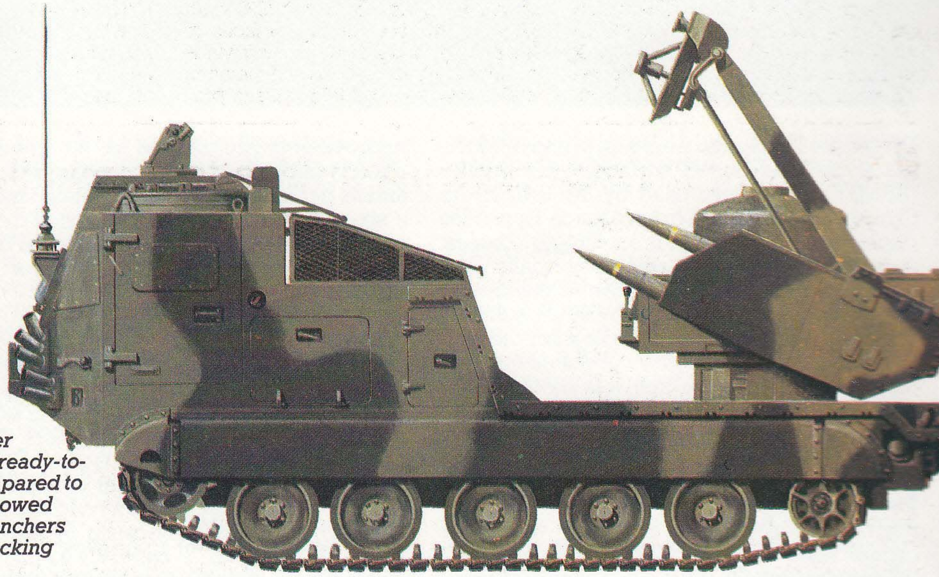
Rapier

Dimensions: length 2.24 m (7 ft 4.2 in); diameter 13.30 cm (5.25 in); span 38.10 cm (15 in)

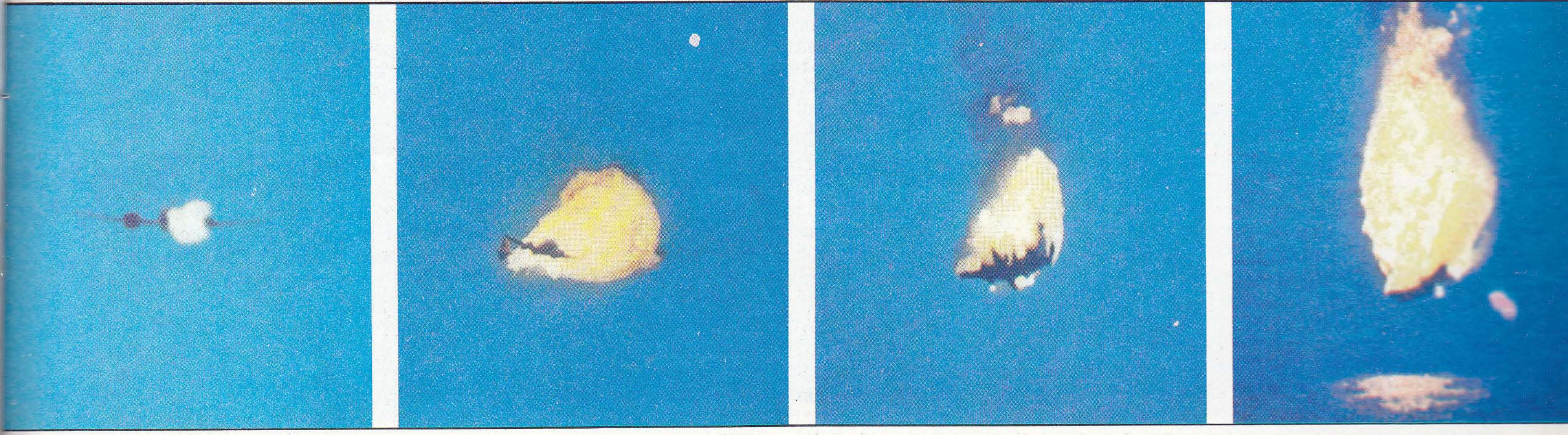
Launch weight: 42.6 kg (94 lb)

Performance: maximum ceiling 3000+ m (9,845+ ft); maximum range 6500+ m (7,100+ yards)

Above: One of the prototypes of the Tracked Rapier launching a missile during trials in the UK. The Royal Artillery will deploy a mix of towed and Tracked Rapiers in the British Army of the Rhine. The first system was delivered late in 1982.



Right: Tracked Rapier has eight missiles in ready-to-launch position, compared to the four of the basic towed version. Here the launchers are elevated with tracking antenna raised.



A Meteor target drone meets a fiery death as a highly effective Rapier missile strikes home.

SAMs in Action in the Falklands

During the Falklands campaign of mid-1982 the following land-based surface-to-air missile (SAM) systems were used by the British: the Shorts Blowpipe, British Aerospace Dynamics Rapier and General Dynamics Stinger. The last is an American weapon, and not normally used by the British, but a small number was supplied during the conflict and used by the Special Air Service (SAS) Regiment as it is lighter than the Blowpipe. Several Stingers were launched, but only one Argentine aircraft was shot down.

The standard man-portable SAM system of the British army is the Shorts Blowpipe, operated by the Royal Artillery with detachments attached to units as required; it is also used by the Royal Marines. The Blowpipe was designed primarily for use in Europe, where the launch team is transported in a Land Rover which also tows a trailer carrying additional missiles; alternatively it is transported in a Spartan armoured personnel carrier. In the Falklands the weapon had to be carried by the gunners who were already laden down with food, clothing and other personnel kit. While Rapier defended the bridgehead at San Carlos some of the Blowpipe teams continued the advance with the infantry formations on foot and, apart from the latter's small arms, were their only air-defence weapons. The system was also successfully used from warships such as the logistic landing ships in San Carlos Water.

During the Falklands campaign Blowpipe is credited with shooting down nine Argentine aircraft, with another two as possibles. According to the British Ministry of Defence Blowpipe was used extensively against fast-crossing targets for which it was not designed and also subjected to a considerable amount of rough handling. Many of the limitations of Blowpipe were known well before the campaign, and the improvement programme for the system was already under way some time ago. The missile and its guidance system will be improved over a six-year period, the first series of modifications being incorporated in missiles to be completed within the next year. The new missile will be called Javelin.

Tight fit

Rapier was deployed by T Battery of the 12th Air Defence Regiment, Royal Artillery, normally based at Kirton-in-Lindsey, Lincolnshire. The battery took 12 Rapier launchers. The unit was followed by No. 63 Squadron, Royal Air Force Regiment (eight Rapier launchers each with a DN181 Blindfire radar) and the 9th Battery, Royal Artillery. Because of the limited space aboard ship, T Battery was allowed to take only 19 vehicles plus trailers, the former consisting of 12 1-tonne Land Rovers, one 1-tonne Land Rover command vehicle, two ¾-ton LWB Land Rovers for use by the troop commanders, one 1-tonne battery quartermaster's supply vehicle and three 1-tonne forward repair team vehicles. Spare parts and missiles were packed on pallets and all loaded aboard the Logistic Landing Ship (LSL) *Sir Geraint*. All second-line repair facilities for the battery had to be left behind in England. None of the equipment was accessible during the voyage to Ascension Island, where four of the launchers were carried ashore by Royal Navy Westland Sea King helicopters. Before this, the battery had exercised only with the Aérospatiale Puma helicopters of the Royal Air Force. One Rapier firing unit needed four lifts (the first with the crew, second with the launcher, third with the 1-tonne Land Rover and optical tracker and the last with the remainder of the stores and nine missiles. To lift the complete battery over 60 helicopter lifts were required. The loss of the *Atlantic Conveyor* was a major blow to the British as three Boeing Vertol Chinook and six Westland Wessex helicopters and a considerable amount of other stores and equipment were lost when this vessel sank on 28 May.

The Rapiers went ashore on 21 May, the first day of the landings, and by that night 10 of the 12 launchers were in position, although some of the equipment was damaged as it was brought ashore by the helicopters; during air raids the helicopters often had to drop their slung loads quickly as they were under fire. The Rapiers were formed in a semi-circle around the southern part of San Carlos Water, and on the second day the remaining fire units were brought ashore. The latter and two of the original units were then redeployed to the northern part of the beach-head. Four days after the original landing a single Rapier fire unit was deployed at Wreck Point to help give support to the hard-pressed Royal Navy ships on the gunline. This launcher had a much better arc of fire compared with the other launchers, which had to engage aircraft at very short range because of the terrain factor.

On 27 May eight Blindfire Rapiers from No. 63 Squadron arrived, and on the following day a troop was deployed by air to Teal Inlet to defend the 3rd Brigade HQ and later another troop was loaded into the LSLs *Sir Tristram* and *Sir Galahad* (two fire units per ship) and sent to Port Pleasant (or Bluff Cove as it is more usually called) to cover the 5th Brigade. These were offloaded on 8 June to cover the HQ and logistic area at Fitzroy Settlement. During the attack on the LSLs by Argentine Skyhawks three of the four fire units were operational and on the third attack two missiles were launched, one kill being obtained.

Left: BAe Dynamics Rapier SAM system deployed at Port Stanley in the Falklands. The surveillance radar is under the dome marked 21C.

Right: Camouflaged Rapier system at San Carlos in the Falklands; it provided vital air defence coverage for both the army and the fleet anchorage.

Far right: Royal Marine with Shorts Blowpipe in the Falklands. It was also used by the British army and the Argentinians.

Below: Amongst the huge quantities of arms captured in Port Stanley were some Soviet-made SA-7 missiles, possibly supplied to Argentina by Libya.

According to the British Ministry of Defence, T Battery shot down 14 Argentine aircraft with a further six claimed as probables. The criterion for a kill was that the aircraft must have been hit and crashed, the kill being witnessed by the member of another unit. The Rapier fire units used by the battery were the early production models and had not been upgraded to the latest standard.

There were no Rapier kills on the first day as much of the time was spent in bringing the equipment ashore, sorting out the stores and setting up the equipment. No attacks were carried out on the second day as a result of bad weather, but on the third day a start was made, one of the most spectacular kills of the campaign being when a Rapier engaged two Skyhawks attacking the liner *Canberra*. The missile hit the lead aircraft, which exploded and destroyed the second aircraft.

Near 'own goals'

Although much of the back-up equipment had had to be left behind, serviceability of the Rapier averaged just under 95 per cent up to the ceasefire. It must also be remembered that Rapier was being used in an operational scenario for which the operators had not been trained and that the Rapiers' surveillance radar was hampered by the much more powerful radars of the warships. Moreover, missiles often had to be pulled off their targets by the operator as the latter were too close to friendly helicopters or ships. Indeed, some reports have said that at least one Royal Navy ship had its mast hit by a Rapier missile. One of the characteristics of the Rapier is that it does not have a proximity fuse and so relies on hitting the target. If it had been fitted with a proximity fuse there is little doubt that a number of ships as well as helicopters would have been damaged, as at times Rapiers were engaging aircraft when friendly helicopters were in the immediate area.

Argentina also used the Blowpipe manportable missile and this is believed to have shot down at least one Royal Air Force BAe Harrier ground-attack aircraft, whose pilot successfully ejected only to be captured by Argentinian troops. Soviet-built SA-7 'Grail' manportable missiles were also found in the Falklands after the conflict, and these are believed to have been supplied to Argentina by Libya. As far as is known none of these missiles was launched. British-supplied Shorts Tigercat missiles, the land-based version of the naval Seacat, were also used by Argentina to defend radar sites; several of these are believed to have been launched against attacking British aircraft, but apparently no hits were obtained.

Argentina did deploy a single Euromissile Roland 2 surface-to-air missile system to the Falklands to protect Stanley airfield against low-level attack. This system was the shelter version, which is much lighter than the version mounted on the tracked Marder of the West German army and the tracked AMX-30 of the French army. The shelter version is mounted on a trailer and therefore has to be towed by a truck or similar vehicle from one position to another, and this limited deployment of the missile system to hard surfaces, of which there are precious few in the Falklands. Whenever possible the shelter system was redeployed around the airfield, and was not knocked out in any of the raids on the airfield. After the campaign the system was sent back to the United Kingdom for evaluation. The shelter-mounted version of the Roland 2 has two missiles in the ready-launch position and a further eight in reserve, in the form of two rotary containers each holding four missiles. The system of operation is identical with that of the tracked Roland 2.

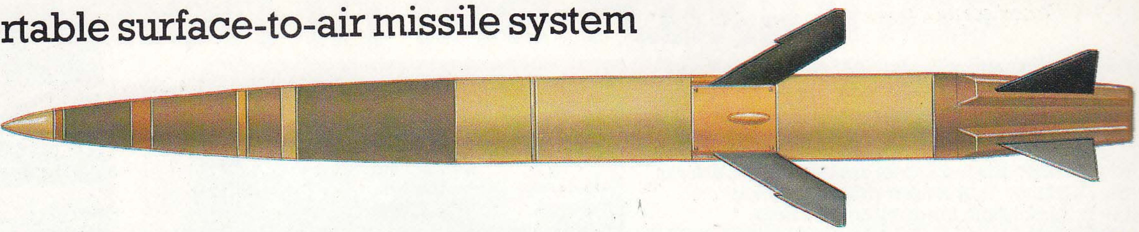
False claims

Euromissile have claimed that this system stopped British air attacks on the airfield at Stanley and shot down four Harriers as well as damaging a fifth. The British Ministry of Defence has firmly denied this, claiming that only one Harrier was shot down by the Roland system while the other three were lost to the anti-aircraft gunfire. According to British sources the latter was the most effective weapon on the Argentinian side during the conflict, with most British aircraft being damaged in some way. Anti-aircraft guns used included the West German Rheinmetall twin 20-mm system and the Swiss Oerlikon-Buhrle twin 35-mm towed system, the latter being used in conjunction with the Contraves Skyguard radar fire-control system. At least one of the latter was knocked out by an anti-radiation missile launched by an aircraft. The USA supplied the United Kingdom with a number of AGM-45 Shrike anti-radiation missiles, which were carried by a number of aircraft (including the Avro Vulcan) and used against surveillance and fire-control radars, including the large Westinghouse AN/TPS-43. The latter was not knocked out although a near miss did tip the antenna over. After the campaign the radar was brought to the United Kingdom, upgraded and integrated into the British air-defence network.

To avoid detection by the Roland, Skyguard and the AN/TPS-43 radars, Royal Air Force Harriers and Fleet Air Arm Sea Harriers used low-flying techniques, radar-warning receivers, ECM, infra-red flares and chaff.

SWEDEN

RBS 70 man-portable surface-to-air missile system



The **RBS 70** SAM system was developed from the late 1960s by AB Bofors to meet the requirements of the Swedish army, although Switzerland did contribute some funds to its development. In addition to being used by Sweden it is now also used by Bahrain, Eire, Norway, Singapore and the United Arab Emirates.

The RBS 70 system consists of three main components, namely the stand, sight and missile in its launch tube, each of which can be transported by one man. The complete system can be assembled in about 30 seconds. If required the RBS 70 system can also be fitted with an IFF system; this has been developed for the Swedish army by SATT Elektronic AB.

The missile is an optical beam rider. The sight generates a modulated laser beam which coincides with the line of sight. Before firing, the operator aims coarsely the line of sight at the target with the whole sight. The missile is then launched from its container and comes into the guidance beam, which it follows until it hits the target. So all the operator has to do is to keep the sight on the target through the engagement, using a thumb lever to control the gyro-stabilized optics.

The missile is launched from the transport/launch tube by means of a booster which burns out in the tube and is then jettisoned. Once the missile has left the tube the fins and control surfaces are extended. The sustainer motor is ignited when the missile is a safe distance from the operator, and this accelerates the missile to supersonic speed. Once the sustainer motor has burned out the missile continues in free flight.

The pre-fragmented warhead contains a large number of heavy metal balls and is detonated either by a direct hit or by means of a proximity fuse when it passes close to the target. It can also be self-destructed by the operator simply by switching off the guidance beam.

The stand consists of a vertical tube, three legs which are folded up for transport, and the operator's seat. There are contacts on the central tube for the electrical connection of the sight, missile, IFF equipment, target data receiver and the operator's headset. The sight consists of the guidance beam transmitter (with zoom optics) and an aiming telescope, all components being specially protected against rough handling.

The RBS 70 can also be used in conjunction with a central search radar which provides target information for a number of missile systems. The Swedish army uses the PS 70/R, or Giraffe, developed by L. M. Ericsson, although other radars can be used, for example the Dutch HSA Reporter. The PS 70/R is mounted on a container which is carried on a cross-country truck; the antenna is mounted on a folding mast which gives the former a height of 12 m (39 ft 4.5 in) above the ground. Each firing unit is then provided with a target data receiver so that it can receive target information (speed and direction) from the radar, the data being transmitted either by radio or land line.

Bofors has also developed a vehicle-mounted system of the RBS 70 which can be fitted on the rear of a Land Rover (4×4) or similar vehicle, and another version for installation on armoured vehicles such as the M113, although by early 1983 neither of these had been placed in production. A helicopter-mounted system is now being proposed to give the helicopter an air-to-air capability against other helicopters.

Bofors RBS 70 SAM being launched from a Land Rover, just one of the many launch platforms for this versatile missile system.

Specification

RBS 70 man-portable surface-to-air missile system

Dimensions: length 1.32 m (4 ft 4 in); diameter 10.6 cm (4.17 in); span 32.0 cm (12.6 in)

Weights: missile in container 24 kg (52.9 lb); stand 23.5 kg (51.8 lb); sight 35 kg (77.2 lb)

Performance: maximum ceiling 3000 m (9,845 ft); maximum range 5000 m (5,470 yards)

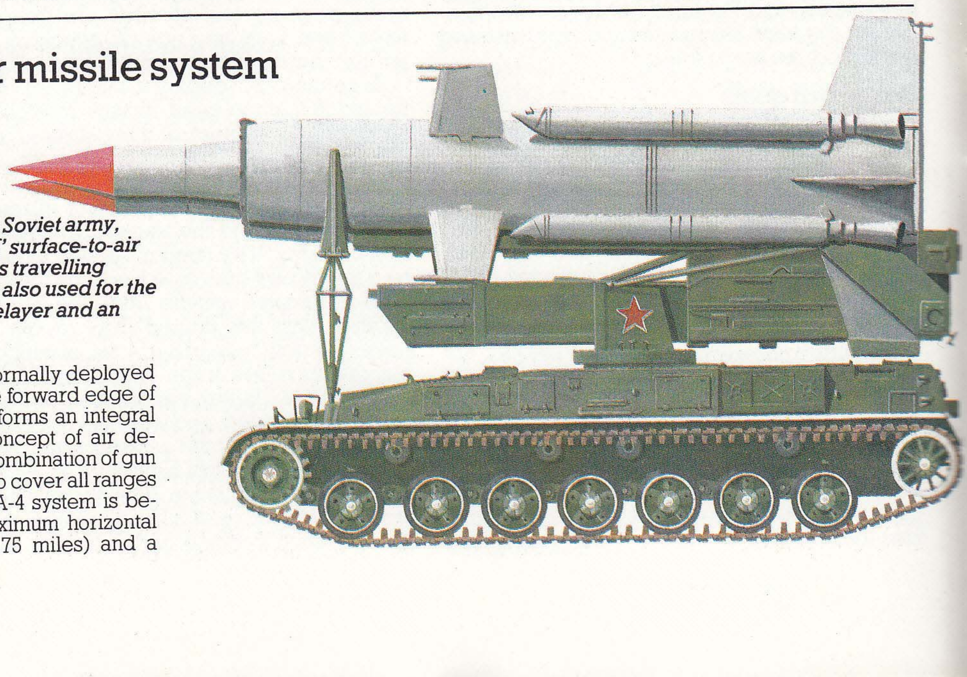
USSR

SA-4 'Ganef' surface-to-air missile system

The **SA-4 'Ganef'** (this being the American designation) medium-to-high altitude SAM system was developed in the late 1950s and was first seen in public during a parade held in Red Square, Moscow, in 1964. The only known operators apart from the Soviet Union are Czechoslovakia, East Germany and Poland. Several units were deployed to Egypt, but these were returned to the Soviet Union before the outbreak of the 1973 Middle East conflict.

The SA-4 system is organized into special brigades each of three battalions, each of the latter having three 'Ganef' batteries and eight ZSU-23-4 self-propelled anti-aircraft guns for close defence. Each battery has three SA-4 tracked launchers, plus one each of the 'Pat Hand' and 'Thin Skin' radars.

The SA-4 system is normally deployed well to the rear of the forward edge of the battle area, and forms an integral part of the Soviet concept of air defence in depth by a combination of gun and missile systems to cover all ranges and altitudes. The SA-4 system is believed to have a maximum horizontal range of 72 km (44.75 miles) and a



Known as Krug in the Soviet army, this is an SA-4 'Ganef' surface-to-air missile launcher in its travelling mode. The chassis is also used for the GMZ armoured minelayer and an SPG.

SA-4 'Ganef' surface-to-air missile system (continued)

minimum horizontal range of 8 km (5 miles), the minimum effective engagement altitude being 1100 m (3,610 ft) and maximum altitude being 24000 m (78,740 ft).

The 'Ganef' transporter/launcher is a fully tracked vehicle based on the chassis of the GMZ armoured minelayer, and this was subsequently adopted for the 152-mm M1973 self-propelled howitzer. Mounted on top of the vehicle is a hydraulically operated turntable carrying the two missiles, the left missile being carried slightly higher than the right one. Before the missiles can be launched they have to be released from their travelling locks, and the coverings over their inlets and nozzles have to be removed.

The missile itself weighs about 1800 kg (3,968 lb) and is fitted with an HE warhead detonated by a proximity fuse. The missile has a length of 9.0 m (29 ft 6.3 in), a diameter of 80.0 cm (31.5 in) and a span of 2.6 m (8 ft 6.4 in). It is launched by four solid-propellant booster rockets mounted externally around the body of the missiles, but once the integral ramjet sustainer ignites these fall away, the missile accelerating to Mach 2.5.

A typical target engagement takes place as follows. The 'Long Track' radar, which is mounted on a modified AT-T heavy artillery tractor, first detects the target and passes target information to the SA-4 battery (it can also pass target information to an SA-6 'Gainful' battery). The 'Pat Hand' fire-control and command guidance radar at the battery then takes over and acquires the target. Once the target is within range, with altitude confirmed by the 'Thin Skin' radar, a 'Ganef' missile is launched and guided to the target by command guidance with semi-active terminal homing for the final stage. Mounted on one of the tail fins of the missile is a continuous-wave radar transponder beacon which enables the missile to be tracked in flight by the 'Pat Hand' radar.

More recently improved missiles have been produced that are more effective at lower altitudes. There are unconfirmed reports that the 'Ganef' has a secondary surface-to-surface capability.

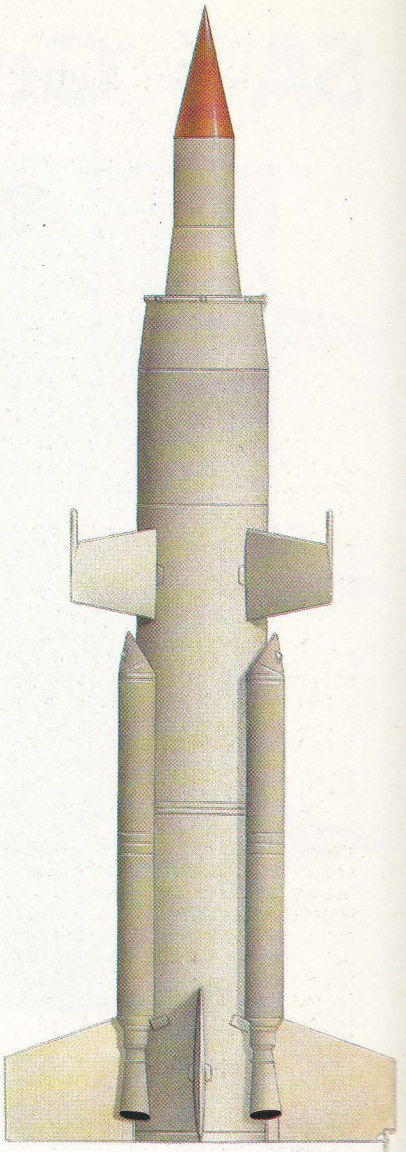
Once the two missiles have been launched new missiles are loaded with the aid of a crane. A Ural-375 (6×6) 4-tonne truck carries one missile, which is so long that it protrudes over the cap of the vehicle. The 'Ganef' system apparently cannot achieve high rates of fire, as according to American sources the battery has only four reload vehicles, each carrying only one missile.

Specification
SA-4 'Ganef'

Dimensions: length 8.8 m (28.87 ft); diameter 0.9 m (35.43 in); tailspan 2.6 m (8.53 ft); wing span 2.3 m (7.54 m)

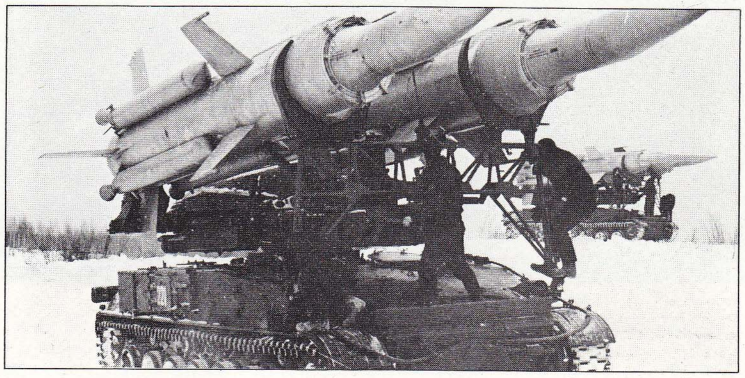
Launch weight: about 1800 kg (3968 lb)

Performance: speed Mach 2.5; range 72 km (44.74 miles); minimum engagement height 1100 m (3600 ft); ceiling 24000 m (78.74 ft)



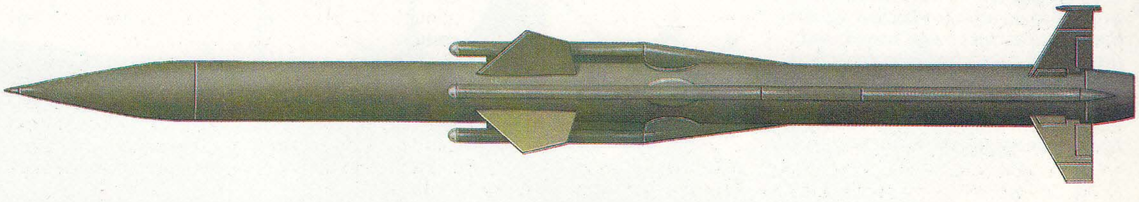
Right: The SA-4 'Ganef' SAM system is used by Bulgaria, Czechoslovakia, East Germany, Poland and the USSR. It was also deployed to Egypt but withdrawn before the 1973 Middle East war. In wartime a fourth launcher is issued to each battery.

Below: SA-4 'Ganef' missiles being prepared for action shortly after coming to a halt. Before launching the intakes are uncovered, travel lock lowered to front of hull and target information received from the command post some way away.



USSR

SA-6 'Gainful' surface-to-air missile system



The **SA-6**, which has been given the NATO reporting name 'Gainful', was first seen in Moscow in 1967 and was first used in action by the Egyptian and Syrian armies during the 1973 Middle East war. The SA-6 was one of the most successful air-defence systems of the campaign and forced Israeli aircraft to fly very low, where they could be engaged by SA-7 man-portable SAMs and the 23-mm ZSU-23-4 self-propelled anti-aircraft gun. The 'Gainful' has been exported on a large scale and in addition to the USSR it is also used by Algeria, Angola, Bulgaria, Cuba, Czechoslovakia, East Germany, Egypt, Ethiopia, Finland, Guinea-Bissau, Guyana, Hungary, India, Iraq, Kuwait, Libya, Mali, Mozambique, Peru, Poland, Romania, Somalia, Syria, Tanzania, Vietnam, Yemen Arab Republic (North Yemen), Yugoslavia and Zambia.

In the Soviet army SA-6s are deployed in regiments, each of these having a regimental HQ with one 'Thin Skin' height-finding and two 'Long Track' surveillance radars and five SA-6 batteries. Each SA-6 battery has one 'Straight Flush' fire-control radar vehicle, four SA-6 launchers and two ZIL-131 (6×6) missile resupply trucks, each carrying three missiles which are loaded with the aid of a crane.

The chassis of the SA-6 system is based on that of the ZSU-23-4, with the crew compartment at the front, the missile-launcher in the centre, and the engine and transmission at the rear. Standard equipment includes an NBC system and night-vision equipment, but the system has no amphibious capability.

The three missiles are carried on a turntable that can be traversed through 360° and provide the missiles with an elevation of about +85°. For travelling the launcher is normally horizontal and traversed to the rear. The SA-6 missile itself is about 6.20 m (20 ft 4 in) long, 33.5 cm (13.2 in) in diameter and 1.52 m (5 ft 0 in) in span across the tail; the missile has a launch weight of about 550 kg (1,213 lb), of which the warhead weighs about 80 kg (176 lb). The missile's propulsion system consists of an integral ram/rocket, the latter being used to launch the missile. When a speed of about Mach 1.5 has been achieved the ramjet takes over and then increases speed to a maximum of Mach 2.8. The original version has a maximum range of about 22000 m (24,060 yards), and an engagement altitude envelope between 100 to 9000 m (330 to 29,530 ft).

A target engagement takes place as follows. The 'Long Track' radar first detects the target and passes target information such as bearing, altitude and range to the SA-6 battery, where the 'Straight Flush' radar takes over. This is based on a similar chassis to that used by the SA-6 and carries out limited search, low-altitude detection/acquisition, target tracking and illumination, missile radar command guidance and secondary radar missile tracking functions. The 'Straight Flush' locates the target and, if this is confirmed as hostile, locks onto it using its tracking and illumination radars. Once this has been accomplished the radar changes to the continuous-wave mode and a missile is launched. The missile receives and transmits information back to the 'Straight Flush' radar, and terminal homing is of the semi-active radar type. The warhead is fitted with a radar proximity fuse as well as an impact fuse, and so does not have to score a direct hit in order to destroy the target.

The basic SA-6 system is now some 20 years old and improved models have recently started to enter service, although the type's replacement could be on hand in the form of the SA-11. The Israelis captured many examples of this system in the 1973 Middle East war and were soon able to devise countermeasures to enable their aircraft to survive over the battlefield, and this information plus a number of complete SA-6 systems were supplied to the United States.

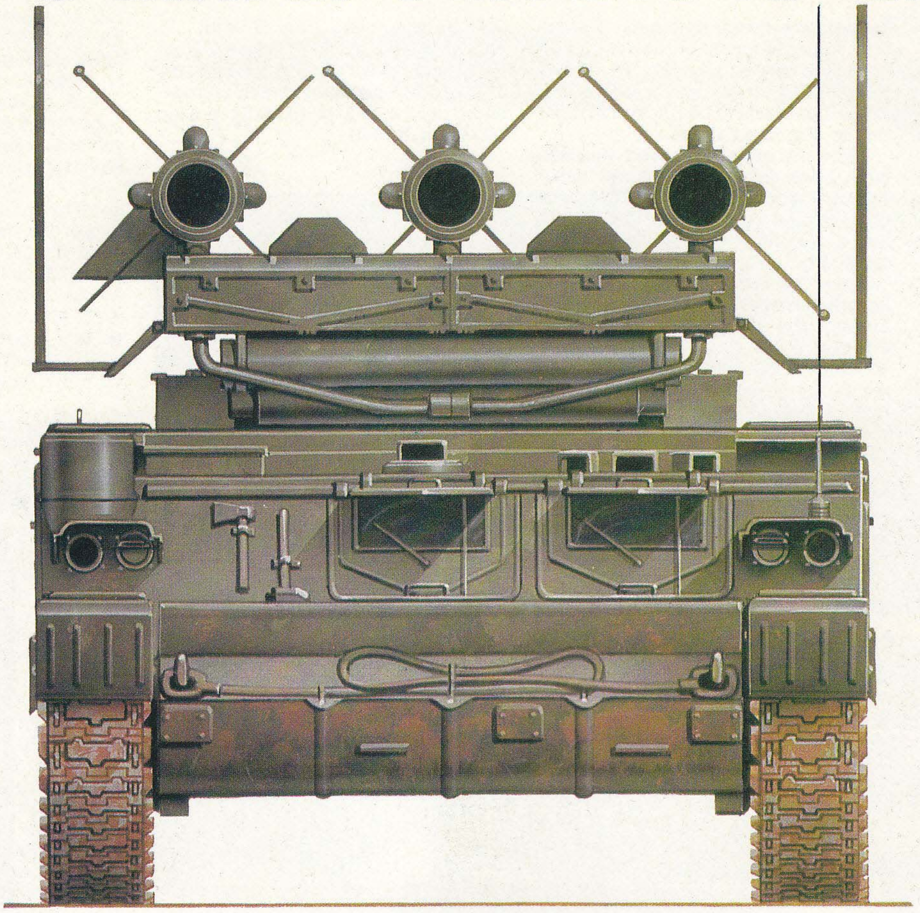
Specification
SA-6 'Gainful'

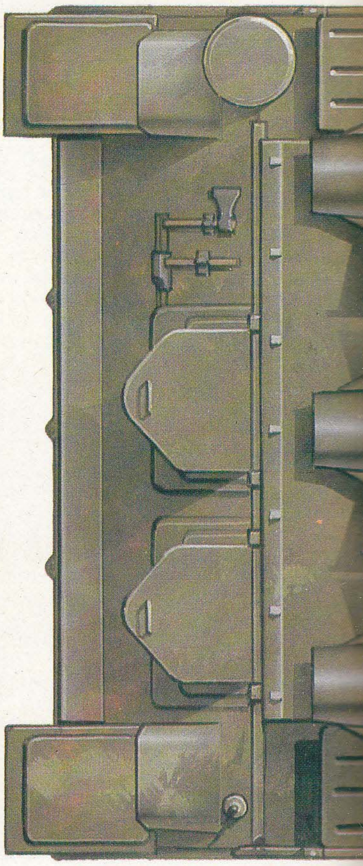
Dimensions: length 6.2 m (20 ft 4 in); diameter 33.5 m (13.2 in); span 1.52 m (5 ft 0 in)

Launch weight: about 550 kg (1212 lb)

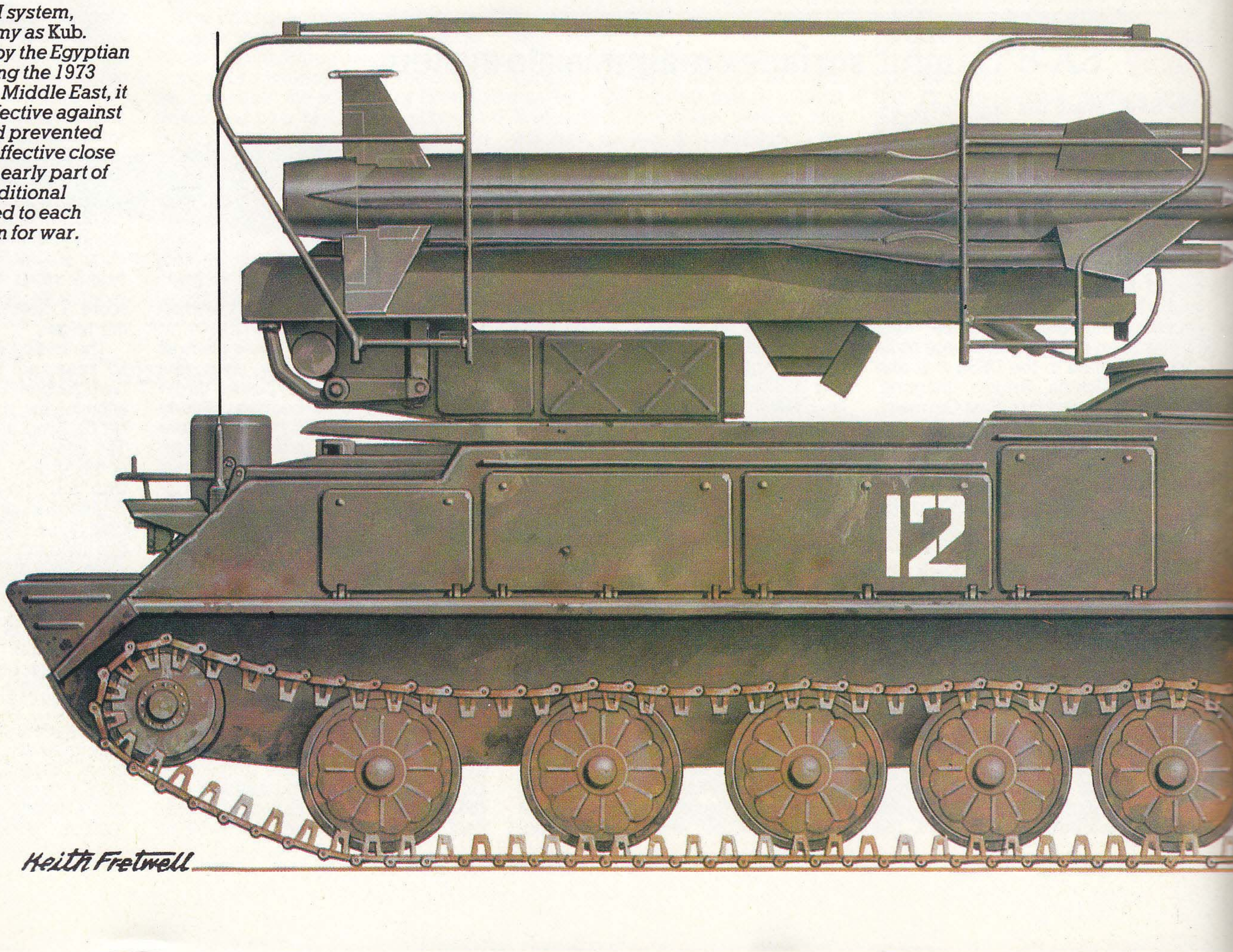
Performance: speed Mach 2.8; maximum range 22-30 km (13.67 to 18.67 miles); range at low level about 60 km (37.34 miles); maximum ceiling up to 18000 m (59,000 ft) according to model

SA-6 'Gainful' surface-to-air missile



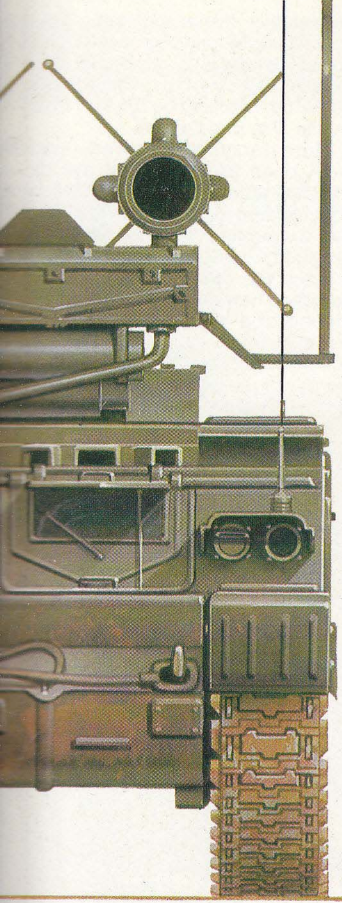


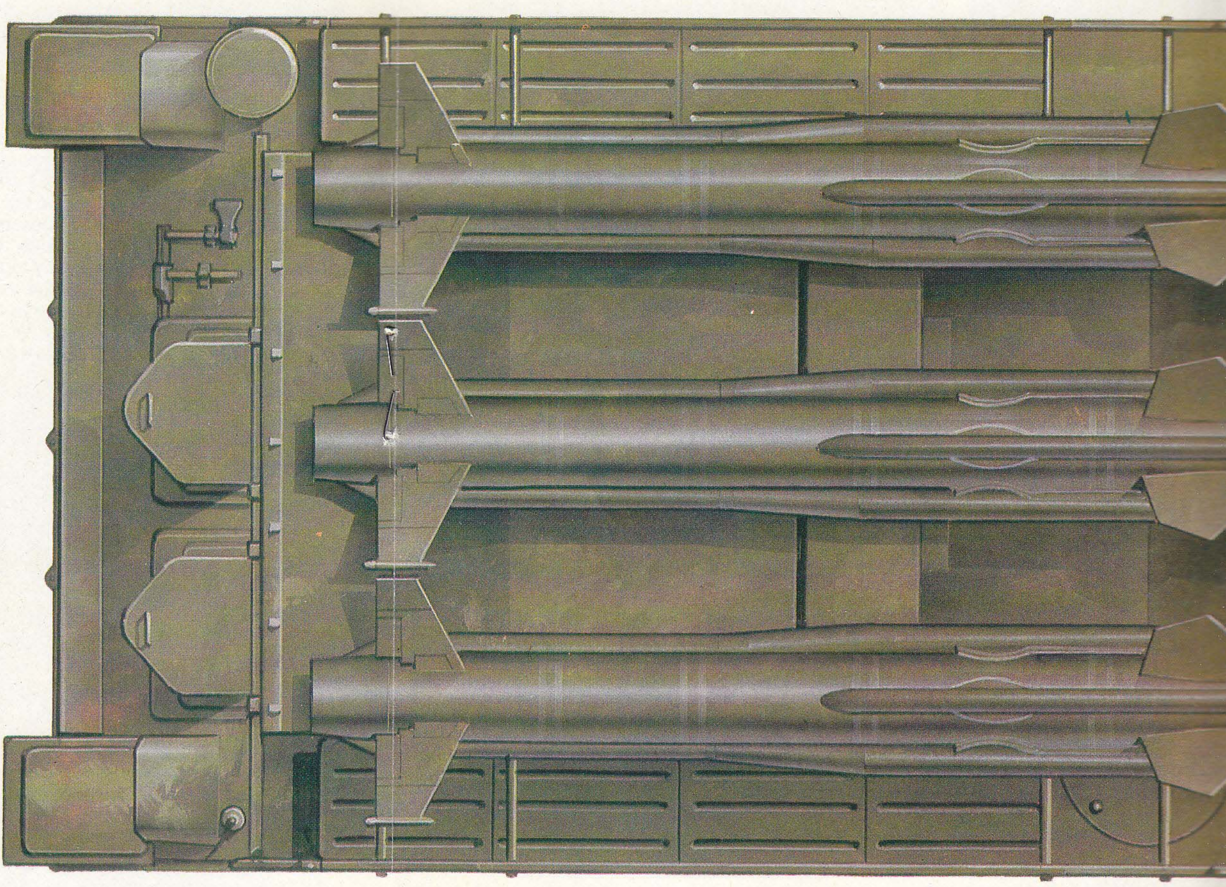
The SA-6 'Gainful' SAM system, known in the Soviet army as Kub. Used for the first time by the Egyptian and Syrian forces during the 1973 Yom Kippur war in the Middle East, it proved to be highly effective against the Israeli air force and prevented them from providing effective close air support during the early part of the campaign. Two additional launchers will be issued to each battery on mobilization for war.

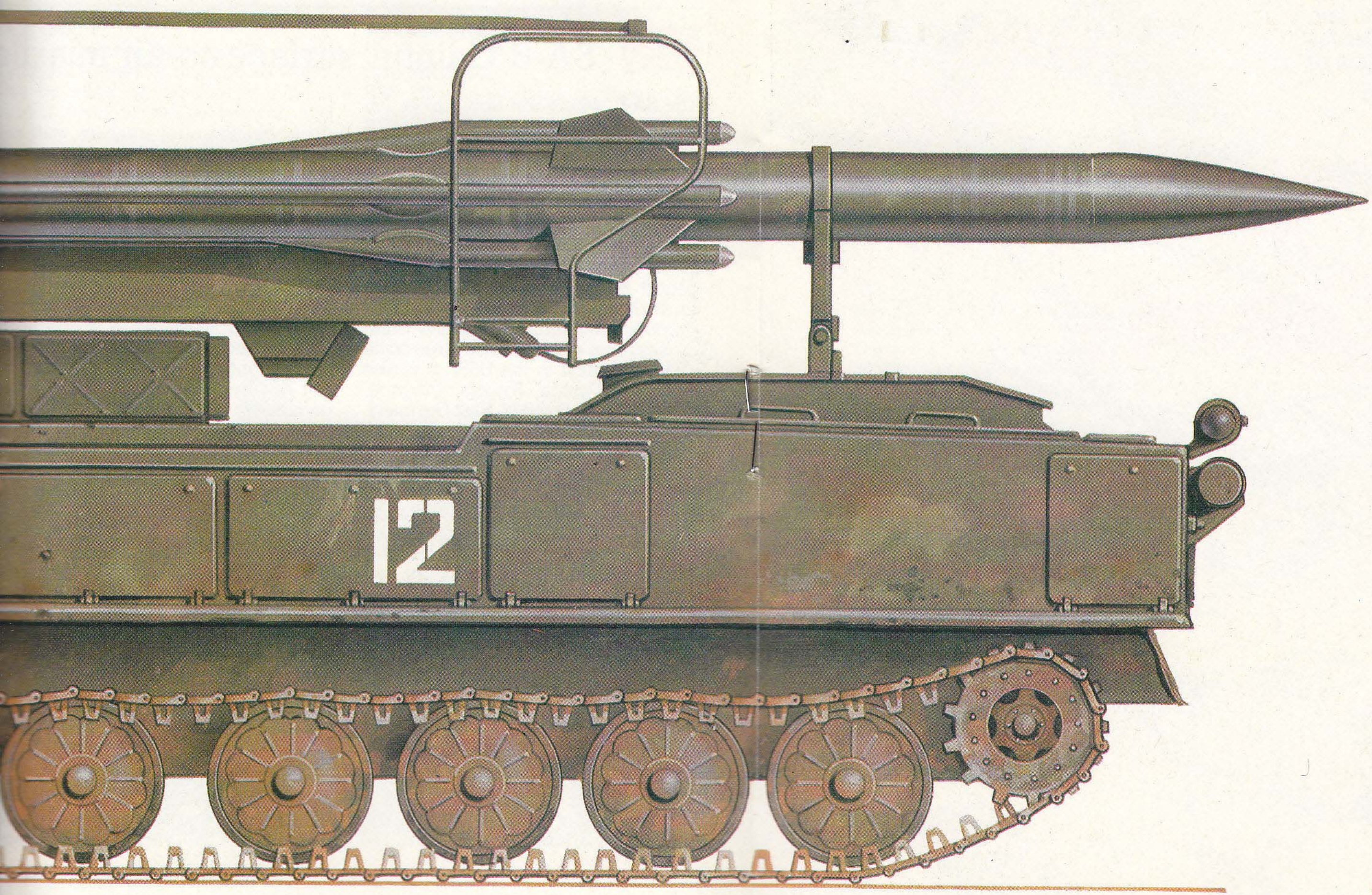


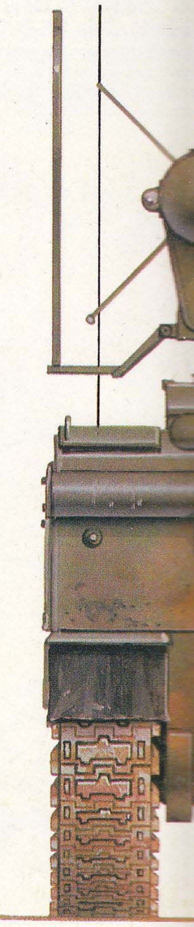
Keith Fretwell

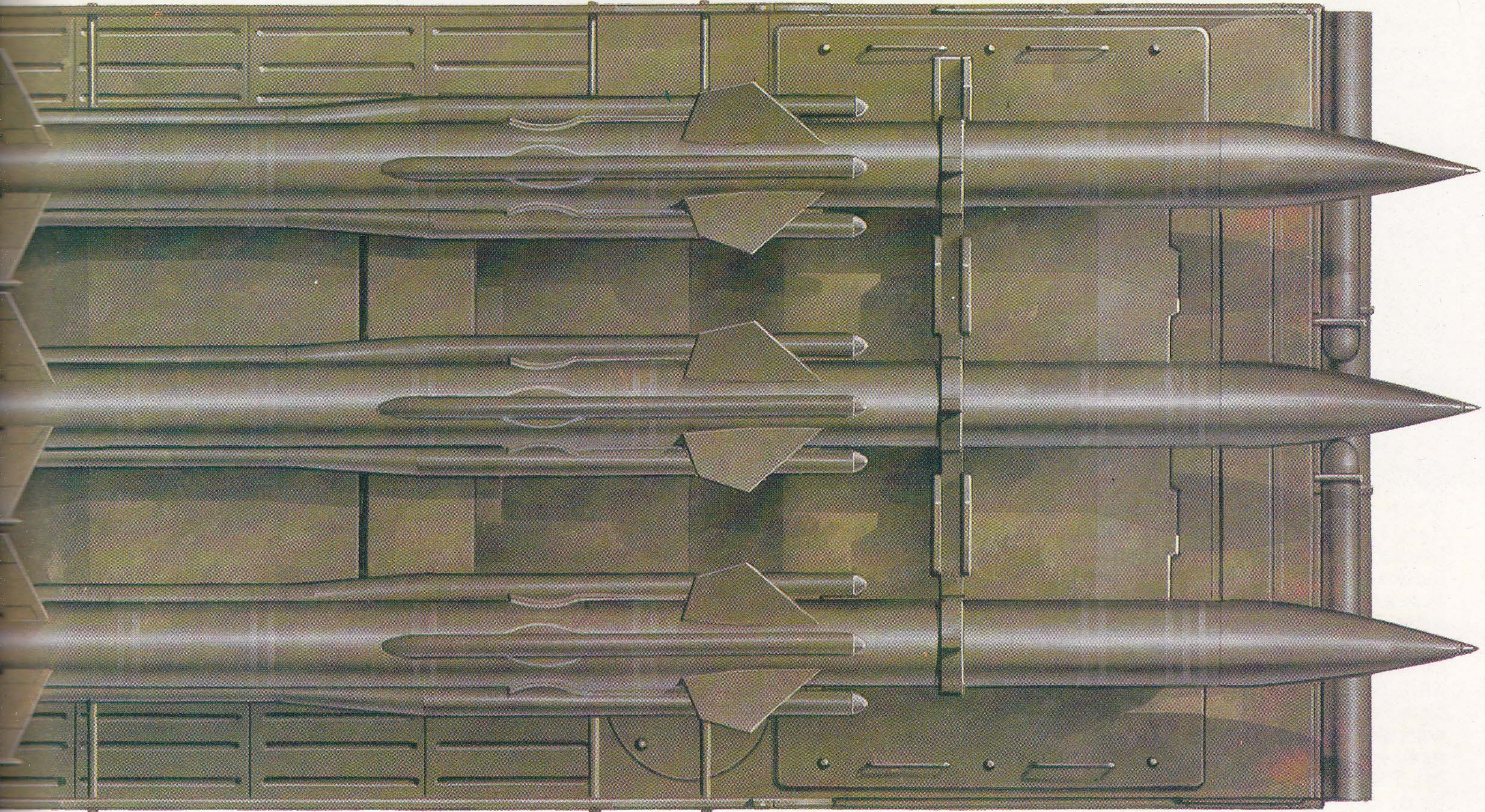
face-to-air missile

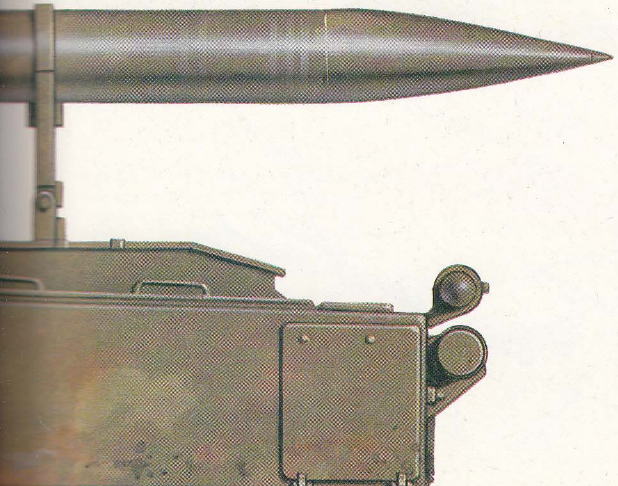


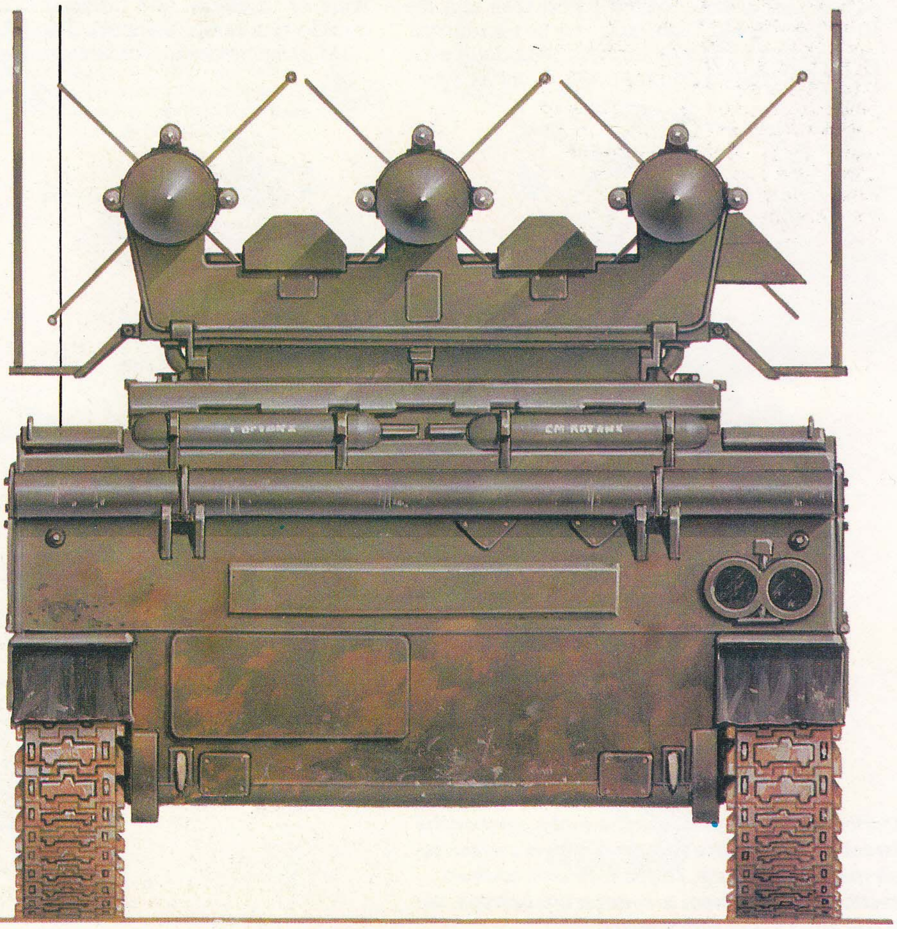












SAMs in Action in the Middle East

Following the Six-Day War in 1967, much Arab effort was devoted to attempts to neutralize the all-conquering Israeli air force. By 1973, Egypt and Syria presented the Heyl Ha'Avir with formidable opposition, and the Yom Kippur War found Israel with no prepared answer to the dense air defence employed.

In the 1973 Middle East war Egypt and Syria made considerable use of the Soviet-supplied SA-2 'Guideline', SA-3 'Goa', SA-6 'Gainful' and SA-7 'Grail' surface-to-air missile systems. Egypt was also supplied with a number of SA-4 'Ganef' missile systems but these were returned to the Soviet Union before the start of the Yom Kippur War. But before this major campaign broke out there was the so-called 'War of Attrition' between Egypt and Israel, during which the Israeli air force struck at targets deep in Egypt. During this time the Egyptians learned a considerable amount concerning the tactics and operational capabilities of the Israeli air force, and the Egyptians soon put this information to good use.

Well before the Yom Kippur War broke out on 6 October 1973, Egypt moved up batteries of SA-2, SA-3 and SA-6 SAMs to the Suez Canal from Port Said in the north to Suez in the south with the SA-2s and SA-3s to the rear and the more mobile SA-6s deployed farther forward. In addition there were anti-aircraft guns of all types, ranging from the 14.5-mm (0.57-in) ZPU-4 up to the 100-mm (3.94-in) KS-19, as well as large numbers of the highly mobile and effective ZSU-23-4 self-propelled quadruple 23-mm anti-aircraft gun. The effective range of this dense belt of missiles stretched well into the Israeli-occupied Sinai and made reconnaissance flights by Israeli aircraft hazardous even before hostilities commenced. In many cases the Egyptians moved forward their equipment under cover of darkness and then camouflaged them so that they could not be detected in the hours of daylight.

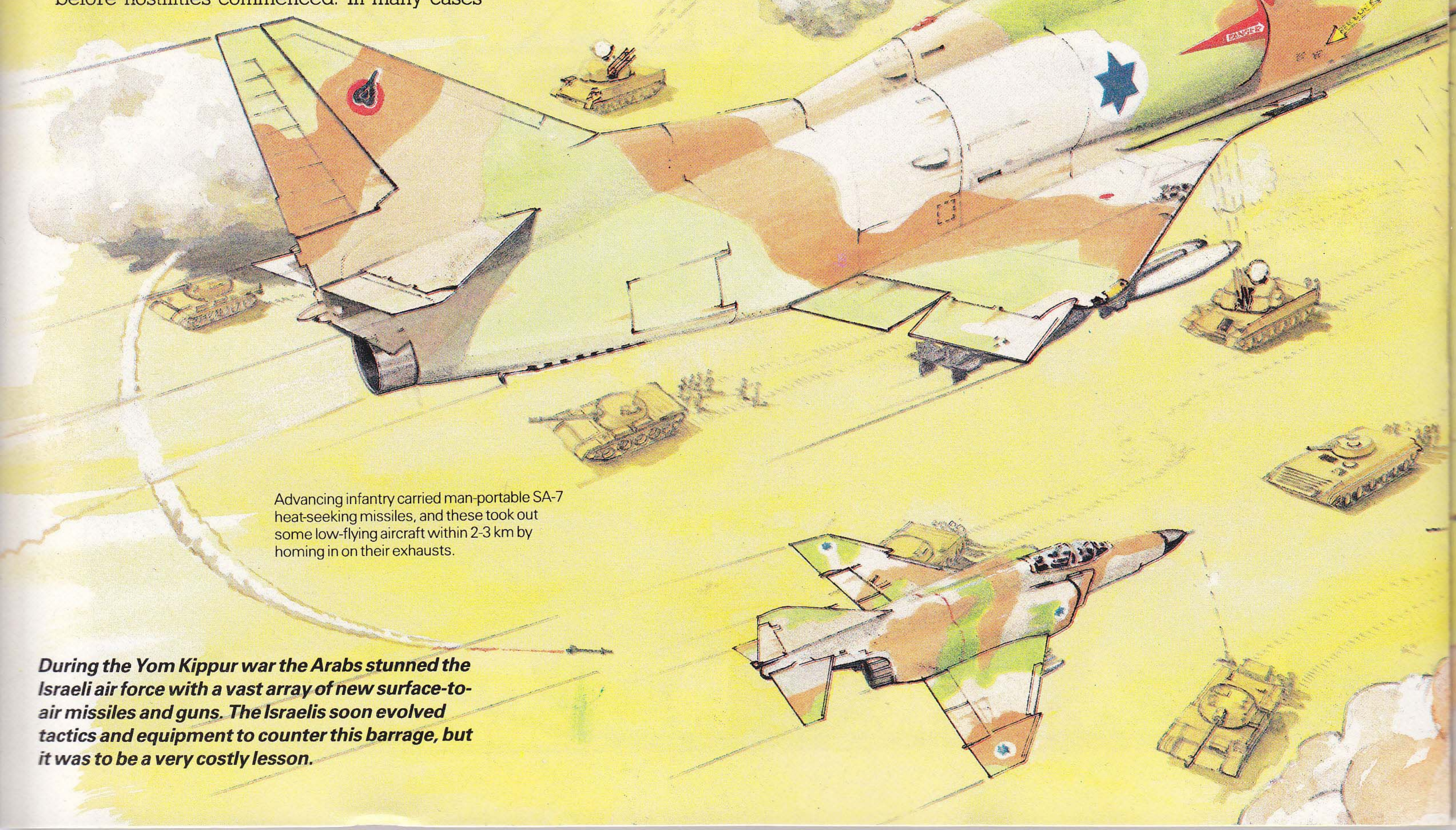
The first waves of Egyptian troops crossed the canal in assault craft and once the banks were secure Soviet-supplied PMP ribbon pontoon bridges were quickly positioned, armoured vehicles and other mechanized equipment then starting to pour across the canal for the push into Sinai. SA-6 'Gainful' SAMs were also soon deployed across the canal to cover the forward advance, and SA-7 'Grail' man-portable SAMs had been issued on a large scale to all units.

Israeli aircraft, especially McDonnell Douglas A-4 Skyhawks and McDonnell Douglas F-4 Phantoms, soon started to attack the forward elements, especially the bridges across the canal, but met with little success owing to the deadly concentration of SAMs and anti-aircraft guns which effectively covered the front from 15 to 15000 m (50 to 49,215 ft). When the Israeli pilots did succeed in hitting one of the pontoon bridges the damaged section was quickly replaced by a new one and material continued to pour across the canal.

Israeli countermeasures

The SA-2s and SA-3s had been used in Vietnam, so their operating modes were well known to the Americans and thus also to the Israelis, and to counter these weapons Israel used chaff and ECM. The former consists of thin strips of metal dropped by aircraft which produces multiple radar reflections and confuses the radar operator as all he sees on his screen is a mass of possible targets. ECM (electronic countermeasures) systems are normally carried in a dedicated aircraft or mounted externally on a combat aircraft (in a pod under the wing or fuselage) and transmit signals to jam missile guidance channels. The SA-6 'Gainful' SAM presented a more dangerous problem as it had not previously been encountered in action and its operational characteristics were not fully appreciated by the Israeli air force. One of the most effective methods to take out the SA-6 was to approach the target at a very high altitude and make a steep diving approach. This method was quite effective as the SA-6 has a fairly low trajectory at launch, but the missile defences were so dense that aircraft were still lost. Helicopters were also used to give warning of the launch of SA-6s so that the aircraft could then take violent evasive manoeuvres; this was found to be effective when two aircraft were being used instead of one. The Israeli air force did take out a number of batteries with air strikes while they were reloading, and also hit the dedicated radars without which the SA-2, SA-3 and SA-6 cannot operate.

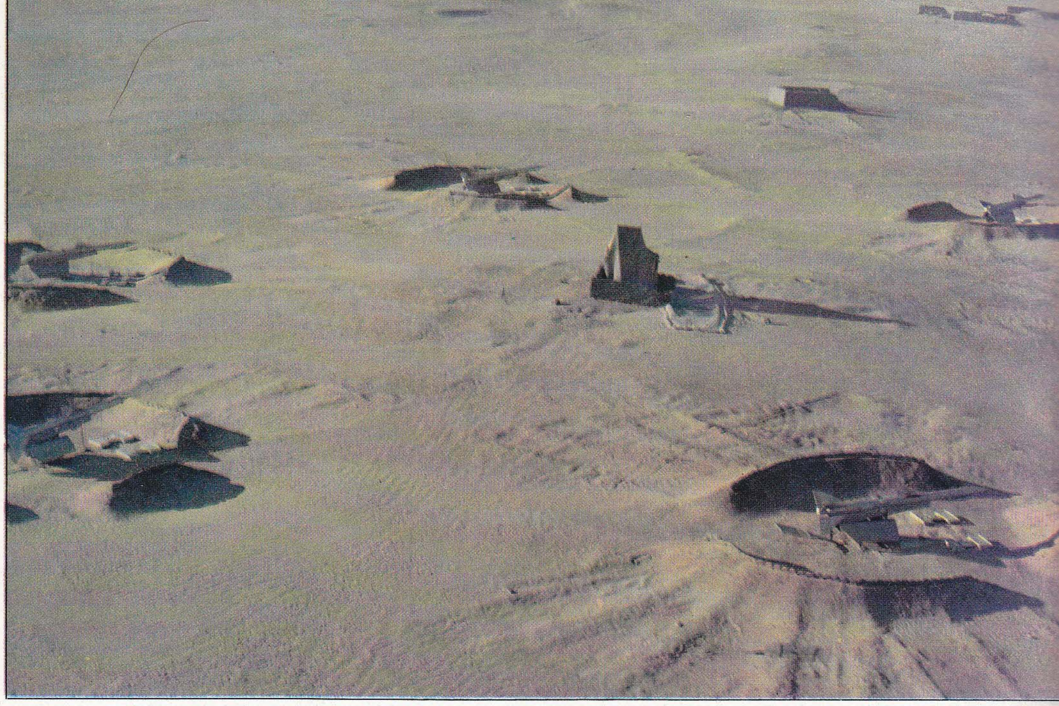
The SA-7 'Grail' was fired in large numbers but it was not responsible for a high number of kills although many aircraft were damaged. This missile had been encountered by Israel before the war and some Skyhawks were given extensions to their tail pipes so that the missile exploded well to the rear of the aircraft. If the SA-7 was spotted early in its flight the pilot could deploy a decoy flare (so that the missile would home onto this rather than onto his exhaust), undertake evasive manoeuvres or even turn towards the missiles. In the earlier War of Attrition one A-4 returned to its base with an unexploded SA-7 in its tail pipe! Today most



Advancing infantry carried man-portable SA-7 heat-seeking missiles, and these took out some low-flying aircraft within 2-3 km by homing in on their exhausts.

During the Yom Kippur war the Arabs stunned the Israeli air force with a vast array of new surface-to-air missiles and guns. The Israelis soon evolved tactics and equipment to counter this barrage, but it was to be a very costly lesson.

Right: Egyptian SA-2 'Guideline' battery with five of the six missile-launchers being shown. Under covers in the centre of the battery is the Fan Song radar system used to launch and control the SAMs.

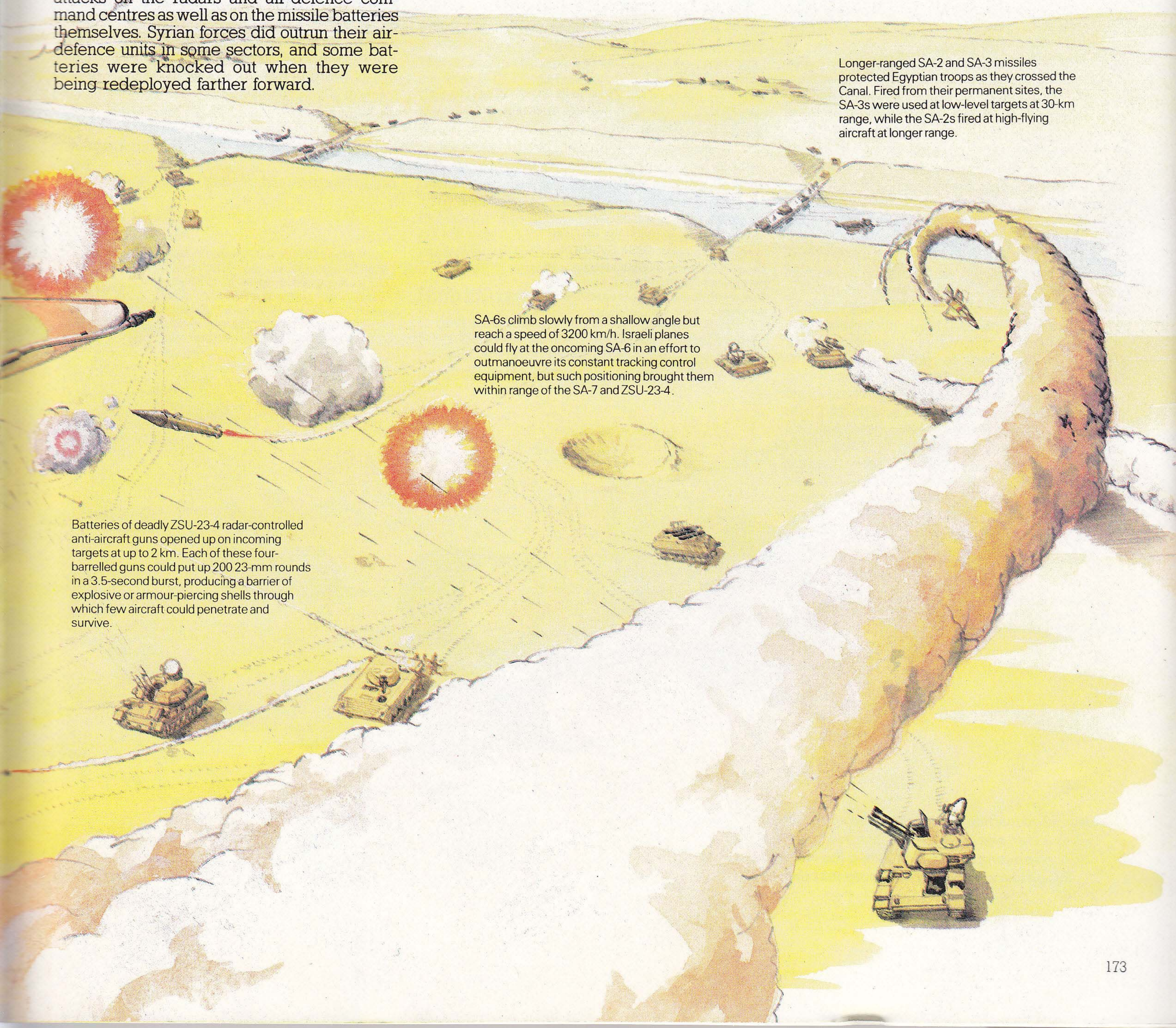


Israeli aircraft have some type of decoy system for the SA-7 and during the fighting in the Lebanon in 1982 Israeli aircraft flying over Beirut were seen to be dispensing flares at a predetermined rate.

During the 1973 war Israel lost about 105 aircraft and two helicopters, of which some 75 per cent were lost during the first few days; only four Israeli aircraft were lost in air-to-air combat.

On the southern front in Sinai, once the Israeli army had recrossed the Suez Canal it was able to capture many of the missile sites by land attack and so open up a gap in the missile belt through which the Israeli air force could once again operate without suffering such high losses.

The situation on the northern Syrian front was similar to that in Sinai, although the terrain was quite different, with the Israeli air force sustaining heavy losses to SAMs in the first few days as it tried to stem the Syrian advance which almost reached the Sea of Galilee. To counter the Syrian air defences the IAF concentrated its attacks on the radars and air-defence command centres as well as on the missile batteries themselves. Syrian forces did outrun their air-defence units in some sectors, and some batteries were knocked out when they were being redeployed farther forward.

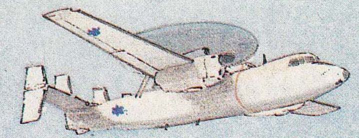


Longer-ranged SA-2 and SA-3 missiles protected Egyptian troops as they crossed the Canal. Fired from their permanent sites, the SA-3s were used at low-level targets at 30-km range, while the SA-2s fired at high-flying aircraft at longer range.

SA-6s climb slowly from a shallow angle but reach a speed of 3200 km/h. Israeli planes could fly at the oncoming SA-6 in an effort to outmanoeuvre its constant tracking control equipment, but such positioning brought them within range of the SA-7 and ZSU-23-4.

Batteries of deadly ZSU-23-4 radar-controlled anti-aircraft guns opened up on incoming targets at up to 2 km. Each of these four-barrelled guns could put up 200 23-mm rounds in a 3.5-second burst, producing a barrier of explosive or armour-piercing shells through which few aircraft could penetrate and survive.

SAMS in Action in the Middle East



Israel controlled the battlefield by using the Grumman E-2C Hawkeye airborne command and control aircraft.

As soon as the war was over many of the captured missile systems, including a number of complete SA-6 'Gainful' batteries, were transported to the United States in Lockheed C-5A Galaxy transports for detailed examination. This enabled the Americans to work out countermeasures to the Soviet missiles, although by that time new models of the SA-6 had no doubt already been supplied to the Soviet forces.

Lebanon 1982

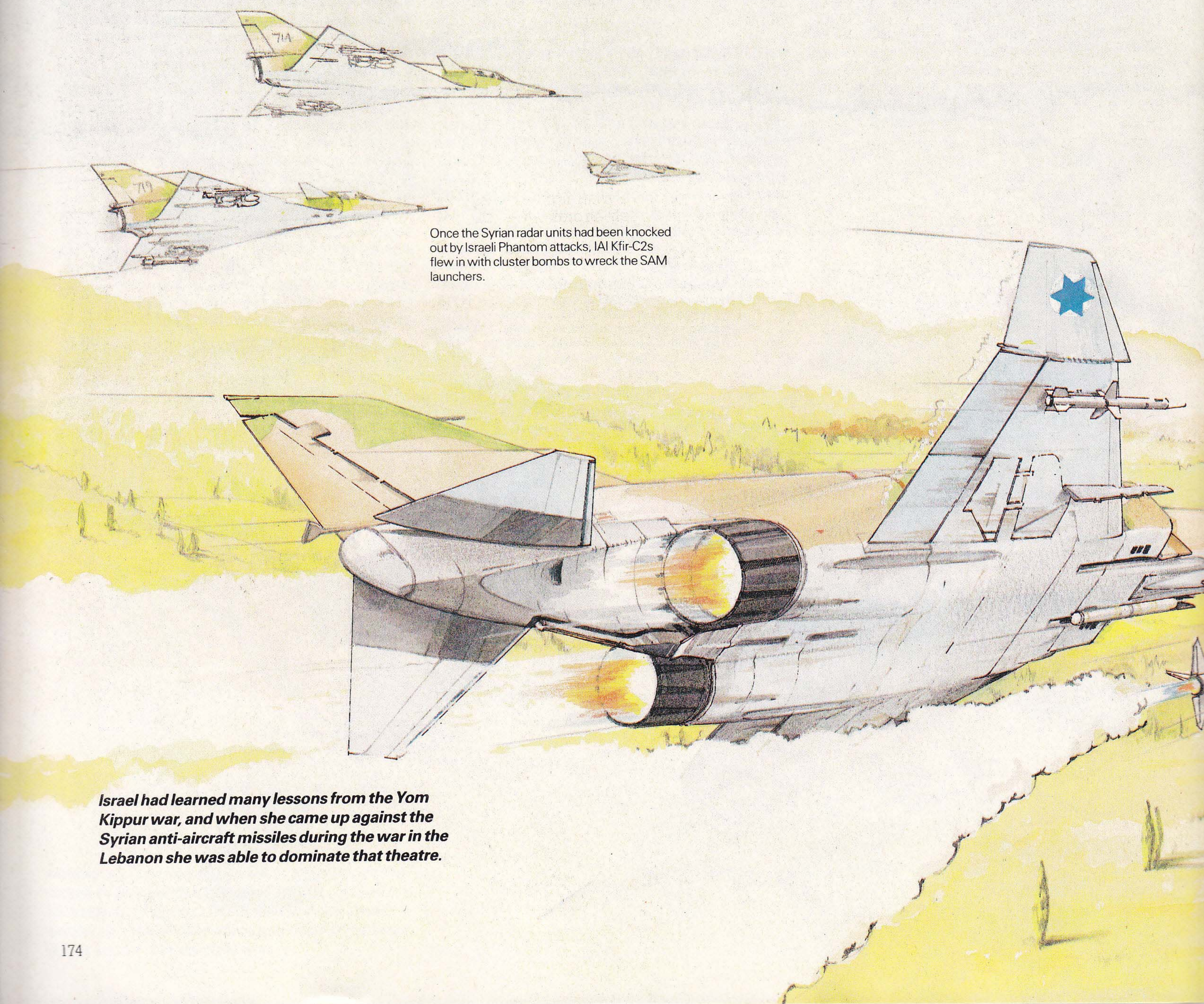
In the Middle East conflict of 1973 Israel's air force had suffered heavy losses in the first few days of the campaign to the Egyptian and Syrian SAMs, but in the June 1982 invasion of Lebanon by Israeli forces the Syrian missile complex in the Bekaa Valley was destroyed without the loss of a single Israeli aircraft.

The Syrian air-defence complex in the Bekaa valley consisted of two SA-2 batteries, two SA-3 batteries and some 15 SA-6 batteries, and had been in position for about 12 months before the Israelis carried out their attack on 9 June. The position of the batteries and their associated equipment had been closely monitored by Israel using RPVs equipped with electro-optical sensors which relayed the data to ground stations in the rear for immediate analysis. It soon became apparent to Israel that with a few exceptions the SAM batteries were static for extended periods and that their exact position could easily be determined.

There were four main parts to the successful attack on the SAM defences in the Bekaa Valley; electronic warfare, deception, attack of the SAM sites, and counter-air operations. For the electronic warfare part a number of Boeing 707s, fitted with a variety of electronic warfare equipment, flew well to the rear (out of range of the missiles) and their equipment automatically identified the missile site radars and then jammed them; communications systems, which are essential in any integrated air-defence system, were also jammed.

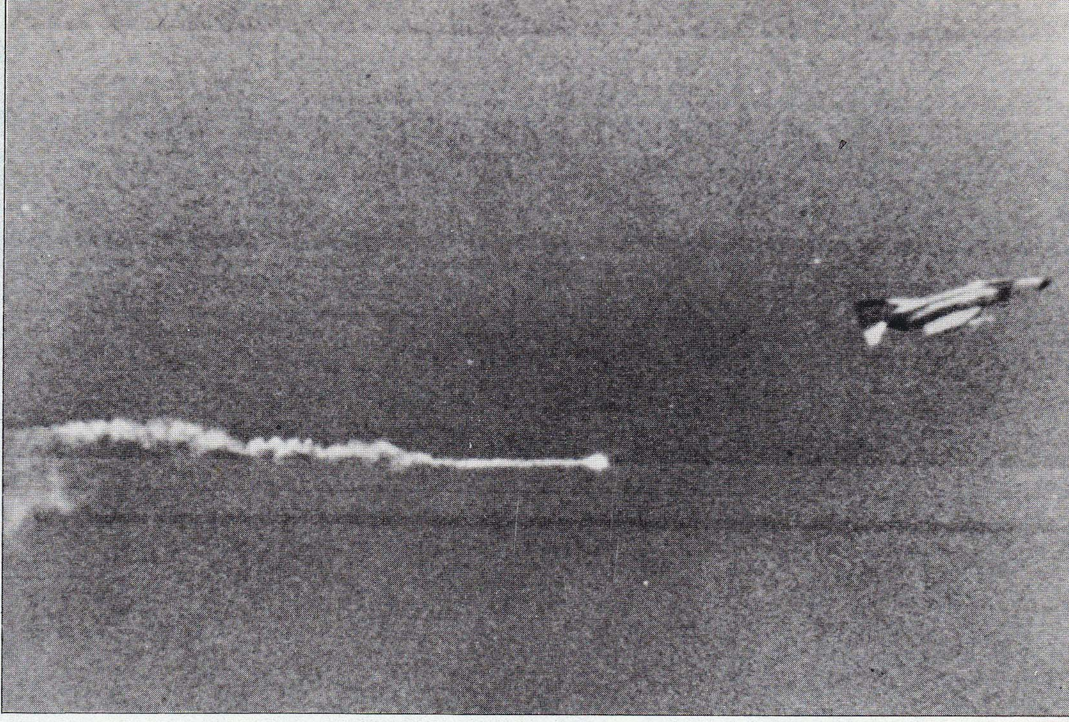
The second stage was to send over numbers of drones to simulate attacking Israeli aircraft. As these approached the Syrian air-defence networks the radars were activated to track them, and shortly afterwards the Syrian batteries started to launch missiles at the drones.

As soon as the Syrian SAMs started to engage the drones, Israeli air force Phantoms, armed with American-supplied AGM-78 Standard ARMs (anti-radiation missiles) and AGM-45 Shrike ARMs (a weapon also used by the British in the Falklands conflict of 1982) attacked each battery. Before the missile is launched, the aircraft carrying the AGM-78, normally a Phantom, receives the hostile radar signal, which is then processed to determine the location and type of target; this information is then passed to the missile, which is then launched



Once the Syrian radar units had been knocked out by Israeli Phantom attacks, IAI Kfir-C2s flew in with cluster bombs to wreck the SAM launchers.

Israel had learned many lessons from the Yom Kippur war, and when she came up against the Syrian anti-aircraft missiles during the war in the Lebanon she was able to dominate that theatre.



In low-level strikes against Palestinian positions, the main danger to the Israeli pilots was from heat-seeking SA-7 missiles. To counter this, aircraft were fitted with magnesium flare dispensers, the heat of the flares diverting missiles away from the aircraft.

and homes onto the target. The Standard ARM is a development of a naval surface-to-air missile, and its solid-fuel dual-thrust motor gives it a much longer range than the earlier AGM-45 Shrike, whose parent aircraft has to approach much closer to the target in order to launch the missile. In addition, the AGM-78 has a much larger HE warhead and can therefore inflict more damage on the target. As soon as the radars of the Syrian SAM batteries were destroyed, waves of strike aircraft, including Skyhawks and Kfir-C2s, went in and attacked the missile sites with standard iron bombs and cluster-type weapons, the latter being of particular use against the batteries which, with their associated supporting equipment (generators, reloaders and command caravans), tend to be spread out. With these techniques 17 out of the 19 batteries are believed to have been destroyed. It is also probable that the RPVs were in the area of the SAM sites during the attacks to enable the Israeli commanders to the rear to monitor the effectiveness of the attacks closely and to confirm exactly which batteries had been destroyed and which were only damaged and therefore needed an additional strike.

To protect it, SAM suppression aircraft of the Israeli air force employed the Grumman E-2C Hawkeye AEW aircraft as an airborne command post with McDonnell Douglas F-15 and General Dynamics F-16 aircraft flying top cover. The E-2C could detect the Syrian Mikoyan-Gurevich MiG-21 and MiG-23 aircraft as they took off from their bases in Syria, and the Israelis were then able to position their aircraft before the Syrians arrived over Lebanon. Syrian fighters rely heavily on ground control to make a successful interception, and the Boeing 707s jammed the communications links between the fighter and ground stations to such effect that often the Syrian fighters had little idea where the Israeli aircraft were coming from until it was too late.

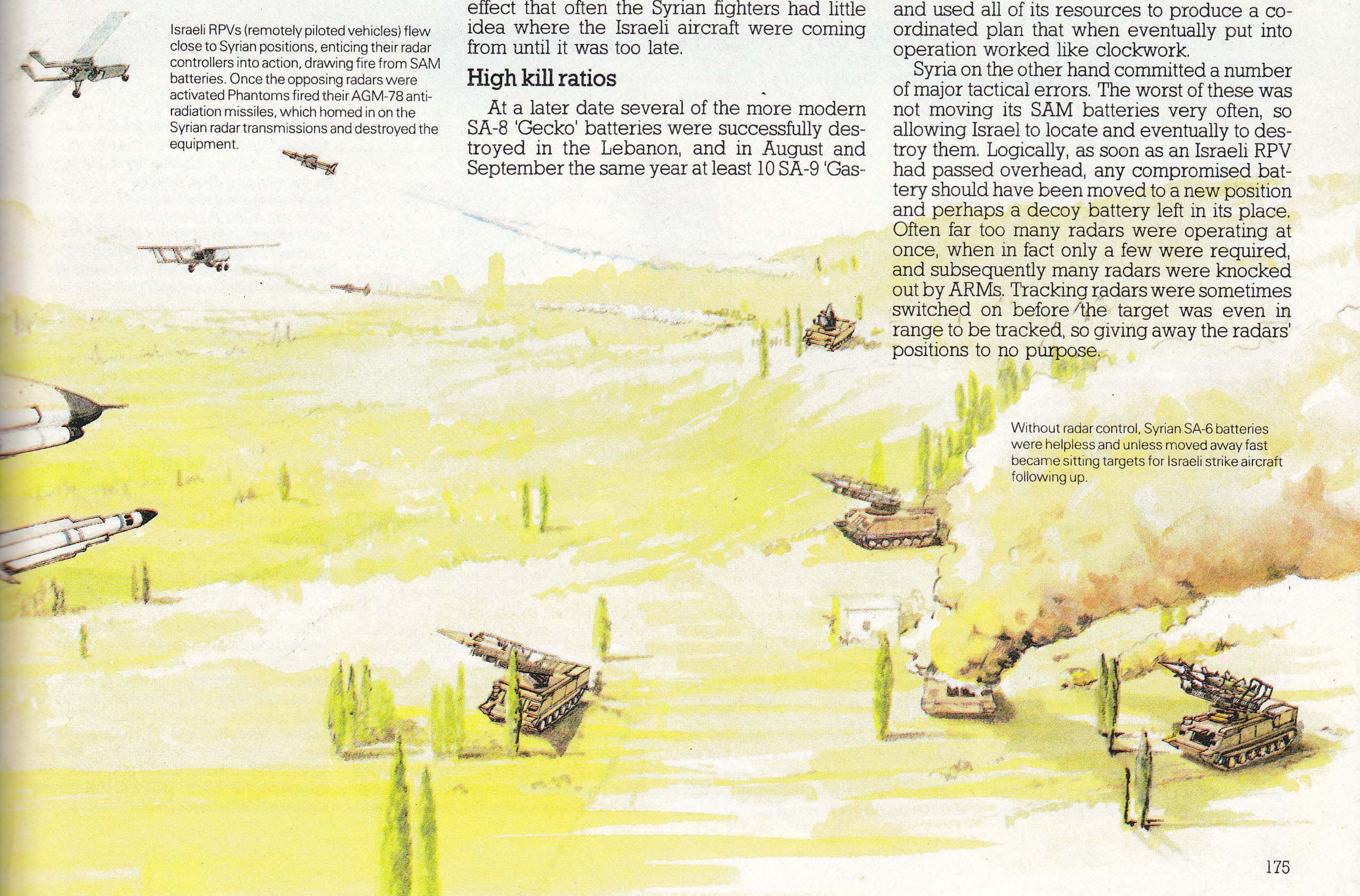
High kill ratios

At a later date several of the more modern SA-8 'Gecko' batteries were successfully destroyed in the Lebanon, and in August and September the same year at least 10 SA-9 'Gaskin' batteries were also destroyed by the Israeli air force.

During the invasion of Lebanon Israel shot down at least 84 Syrian aircraft while their own losses amounted to one RF-4E Phantom reconnaissance aircraft, one A-4 Skyhawk and one Bell AH-1 Cobra anti-tank helicopter.

When the initial reports of the Israeli success in defeating the Syrian SAM defences in the Bekaa Valley were disclosed, it was widely believed that Israel had invented some new weapons, but this was not the case. Over some time Israel had carefully analysed the situation and used all of its resources to produce a coordinated plan that when eventually put into operation worked like clockwork.

Syria on the other hand committed a number of major tactical errors. The worst of these was not moving its SAM batteries very often, so allowing Israel to locate and eventually to destroy them. Logically, as soon as an Israeli RPV had passed overhead, any compromised battery should have been moved to a new position and perhaps a decoy battery left in its place. Often far too many radars were operating at once, when in fact only a few were required, and subsequently many radars were knocked out by ARMs. Tracking radars were sometimes switched on before the target was even in range to be tracked, so giving away the radars' positions to no purpose.

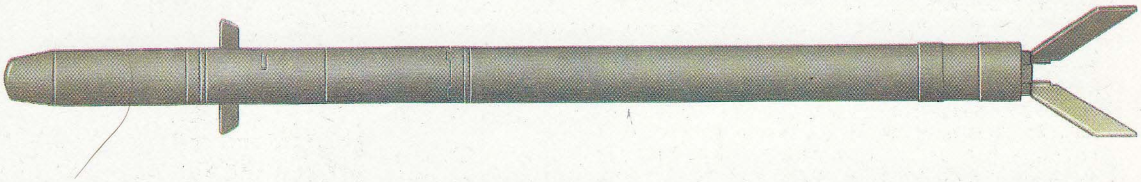


Israeli RPVs (remotely piloted vehicles) flew close to Syrian positions, enticing their radar controllers into action, drawing fire from SAM batteries. Once the opposing radars were activated Phantoms fired their AGM-78 anti-radiation missiles, which homed in on the Syrian radar transmissions and destroyed the equipment.

Without radar control, Syrian SA-6 batteries were helpless and unless moved away fast became sitting targets for Israeli strike aircraft following up.

USSR

SA-7 'Grail' man-portable surface-to-air missile system



The **SA-7 'Grail'** man-portable SAM was developed in the early 1960s and is similar in concept to the US Redeye missile. It was first used in combat in the 1967 Middle East war, and has been issued to every member of the Warsaw Pact, most countries that have received Soviet aid and many guerrilla factions around the world. It is operated by a two-man team consisting of the gunner, who carries a gripstock and one missile in a canvas bag, and an assistant gunner who carries an additional missile.

The SA-7 system consists of the missile in its launcher, thermal battery and a reusable gripstock. The missile itself has an infra-red seeker head, two canard fins at the front and four spring loaded tail fins that stabilize the missile in flight. The gripstock assembly is attached to the underside of the forward part of the launcher, and contains the trigger mechanism, safety switch, locking pin and an audible alarm. The circular thermal battery is attached to the forward part of the gripstock assembly by a key slot which contains four locking pins.

A typical target engagement takes place as follows. Once the operator has sighted a target he removes the end cap of the launch tube and points the launcher at the target. The trigger has two stages of operation, the first stage switching on the thermal battery. When the missile has picked up sufficient infra-red radiation from the target an audible warning is given and a light also comes on. The trigger is then pulled right back and the missile is ejected from the launcher by a motor which burns out before the tail of the missile has left the launcher. A rocket booster then accelerates the missile to Mach 1.5 and the sustainer takes over. The infra-red seeker then homes onto the exhaust of the aircraft or helicopter. The missile is fitted with a direct-action and graze fuse, and therefore has to hit the target in order to detonate. The warhead contains RDX/AP explosive but from all accounts this will damage the aircraft rather than destroy it. If the missile has not hit its target after a period of 15 seconds or a range of about 6.5 km (4.04 miles) it will self-destruct. There are many accounts of Israeli aircraft, especially McDonnell Douglas A-4s, that returned with damaged tailpipes. Fresh missiles are delivered to the unit in wooden boxes which contain two missiles and four thermal batteries.

The SA-7 has a maximum speed of 1600 km/h (994 mph) and a maximum range and altitude of about 3.2 km (2 miles), while the later-production **SA-7B** has a maximum speed of 1930 km/h (1,200 mph) and a maximum altitude of about 4800 m (15,750 ft). When originally introduced the system was not fitted with an IFF system and the crew had therefore to make a positive identification before launching a missile, but later models were fitted with a IFF system. The SA-7B has a 28-pin connector between the gripstock and the launcher whereas the original model has a 24-pin connector.

The SA-7 missile has many limitations including its infra-red seeker, which tends to make it chase the aircraft, its relatively low speed and altitude, its limited manoeuvrability, its somewhat protracted warming-up period and its lack of an IFF system. All these make the SA-7 a somewhat ineffective weapon against combat aircraft moving at more than 925 km/h (575 mph). The threat of the SA-7 does, however, force pilots to fly at a higher altitude, where they can be engaged by other anti-aircraft systems.

Specification
SA-7 'Grail'

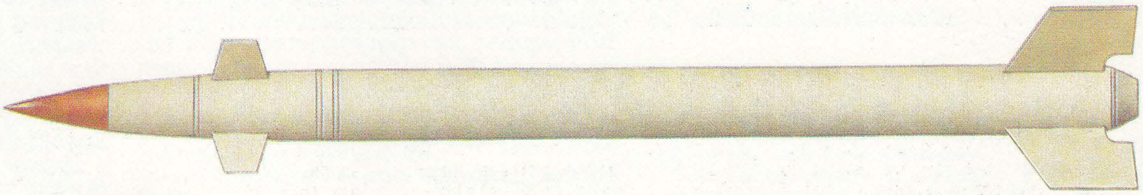
Dimensions: length of missile 1.30 m (4 ft 3.2 in); diameter about 7.0 cm (2.75 in); length of launcher 1.346 m (4 ft 5 in)

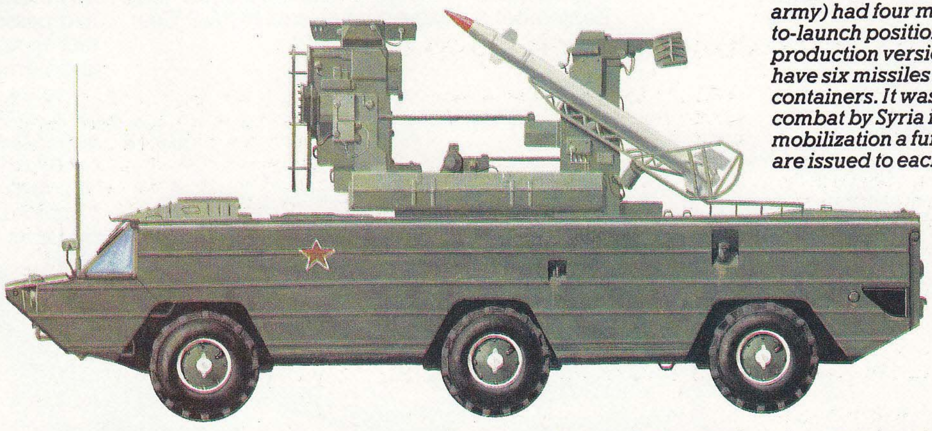
Weights: launcher 10.6 kg (23.4 lb); missile 9.2 kg (20.3 lb)

Performance: effective altitude between 45 and 1500 m (150 and 4,920 ft); range 3.2 km (2 miles)

USSR

SA-8 'Gecko' surface-to-air missile system





***Left:** The first version of the SA-8 'Gecko' (called* Romb *in the Soviet army) had four missiles in the ready-to-launch position but the production version is believed to have six missiles in launch/transport containers. It was first used in combat by Syria in mid-1982. On mobilization a further two launchers are issued to each battery.*

The **SA-8 'Gecko'** low-altitude surface-to-air missile system was first deployed in the early 1970s, and was first seen in public during a parade held in Red Square, Moscow, during 1975. Unlike earlier Soviet self-propelled air-defence missile systems, the SA-8 'Gecko' is completely self-contained in that it has its own tracking and surveillance radars and so can therefore operate on its own. In the Soviet army it is now rapidly replacing the 57-mm S-60 towed anti-aircraft gun, each division having five batteries each with four SA-8s and four missile resupply vehicles. At HQ level there is one 'Thin Skin' height-finding and two 'Long Track' surveillance radars for command and control. The system is also used by Jordan and Syria, and the latter country used the SA-8 operationally for the first time in the Bekaa Valley in the Lebanon during 1982.

The system is mounted on a 6×6 chassis which is believed to be a development of the ZIL-167 vehicle; this is fully amphibious, being propelled in the water by two waterjets at the rear of the hull. Steering is on the front and rear axles and a central tyre-pressure regulation system allows the driver to adjust the tyre pressures to suit the type of ground being crossed. The crew compartment, which is provided with an NBC system, is at the front of the hull, with the missile system in the centre, and the engine and transmission at the rear.

The missile system can be traversed through 360° and has two missiles in the ready-to-launch position on side at the rear, surveillance radar with a range of 30 km (18.6 miles) on top (when travelling this can be lowered horizontally to the rear), and the missile guidance group at the front. The last consists of the large central tracking radar with a smaller missile-guidance radar and a command-link horn for missile-gathering on each side. Mounted above each missile guidance radar is a low-light-level television/optical assistance system, which is believed to be used for tracking in conditions of either low visibility or heavy electronic countermeasures. Why the system has two tracking and two guidance radars is not completely clear, but it is probably to allow a salvo of two missiles to be launched at a target, with a gap between launchings, to give a higher kill probability. The missiles are believed to have infra-red and semi-active seekers.

The missile has a launch weight of 190 kg (419 lb) and is 3.20 m (10 ft 6 in) long, 21.0 cm (8.25 in) in diameter and 64.0 cm (25.2 in) in span. The solid-propellant single-stage rocket motor produces a maximum speed of Mach 2. Minimum and maximum target engagement altitudes are 50 m (165 ft) and 13000 m (42,650 ft), and maximum slant range is about 12 km (7.5 miles).

More recently an improved version of the SA-8 has been seen, and this has been given the Western designation **SA-8B.** This has six missiles in the ready-to-launch position, and these, which are possibly longer and have increased capabilities, are carried in fully enclosed containers. The latter provide the missile with increased environmental protection as well as giving the missile protection against rough handling in the field. The SA-8 launcher system has no integral reload capability.

Specification
SA-8 'Gecko'

Dimensions: length 3.2 m (10 ft 6 in); diameter 21.0 cm (8.25 in); span 64 cm (25.2 in)

Launch weight: 190 kg (419 lb)

Performance: speed Mach 2; range 12 km (7.5 miles); minimum engagement height 50 m (164 ft); maximum ceiling 13000 m (42,650 ft)

USSR

SA-9 'Gaskin' surface-to-air missile system

The **SA-9 'Gaskin'** low-altitude SAM system was developed in the 1960s and was first seen in public in the 1970s. It is deployed in the Soviet Army on the scale of 16 systems per division, with each regiment, be they tank or motorized rifle, having four systems. In addition to being used by the Soviet Union the SA-9 is also used by many other countries including Algeria, Egypt, East Germany, Hungary, India, Iraq, Libya, Poland, South Yemen, Syria, Vietnam and Yugoslavia. The first known operational use of the SA-9 system was in Lebanon in May 1981 when an SA-8 battery manned by Libyans engaged Israeli aircraft. The battery was subsequently destroyed by the Israeli air force without loss. The type has also been used operationally by Iraq against Iranian aircraft during the recent conflict.

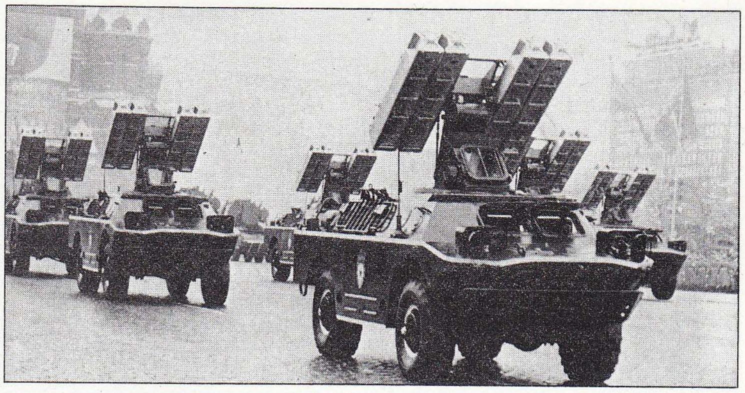
The SA-9 'Gaskin' system is essentially the BRDM-2 (4×4) reconnaissance vehicle with its one-man machine-gun turret removed and replaced by a new power-operated turret. In the forward part of this is a seat for the operator, who is provided with a large transparent window to his front. To the rear of the operator is a pedestal and on each side of this are two missiles in their ready-to-launch containers. When the vehicle is travelling, the launcher and its associated missiles lie horizontally along the top of the hull. Once the four missiles have been launched the empty canisters have to be removed, and new missiles in their containers are then loaded manually by the crew from outside the vehicle. As far as it is known the SA-9 retains the amphibious characteristics of the BRDM-2 and is fitted with two belly wheels between the front and rear axles, allowing it to cross trenches with ease.

It is believed that the missile is a further development of the SA-7 manportable missile but fitted with a more powerful rocket motor for increased performance and a longer range. It is probable that target engagement is similar to that of the SA-7 but with two missiles launched at each target (with gap of five seconds) for a higher kill probability. The missile's infra-red seeker is set to operate against different target intensities in order to defeat flare-type decoys launched by the target aircraft.

The missile itself is carried and launched from a container that protects it during handling, and is about 1.829 m (6 ft 0 in) long, 11.0 cm (4.33 in) in diameter and 30.0 cm (11.8 in) in span. It has an effective range of 8000 m (8,750 yards) and a maximum engagement altitude of 4000 m (13,125 ft). The missile is believed to weigh about 30 kg (66 lb) and to have a maximum speed of more than Mach 1.5.

The SA-9 'Gaskin' has a number of major drawbacks in that it is a clear-weather system only and the gunner must traverse his turret continuously on the look out for targets, although initial target information such as direction, speed and altitude are probably provided from a central command post. The rate of fire is slow as the missiles have to be reloaded manually. For some years there have been unconfirmed reports that the SA-9 is being fitted with the 'Gun Dish' radar (as fitted to the ZSU-23-4 self-propelled anti-aircraft gun system) to give the system an all-weather capability. This radar, which is probably mounted above the turret, carries out target-acquisition and tracking functions to a maximum range of about 20 km (12.4 miles).

Because of its limitations the SA-9 is now being replaced by the SA-13 system, which has its own radars and carries four missiles in the ready-to-launch position.



An SA-9 'Gaskin' system, based on the BRDM-2 (4×4) amphibious scout car, parades through Red Square, Moscow.

Specification

SA-9 'Gaskin' launcher system

Crew: 3

Weight: 8000 kg (17,635 lb)

Dimensions: length 5.75 m (18 ft 10.4 in); width 2.35 m (7 ft 8.5 in); height (travelling) 2.35 m (7 ft 8.5 in)

Powerplant: one GAZ-41 V-8 water-cooled petrol engine developing 140 hp (104 kW)

Performance: maximum road speed 100 km/h (62 mph); maximum range 750 km (466 miles); fording amphibious; gradient 60 per cent; vertical obstacle 0.4 m (15.75 in); trench 1.25 m (4 ft 1 in)

USSR

SA-11 surface-to-air missile system

The **SA-11** is the replacement for the SA-6 'Gainful' SAM system, which has now been in service for almost 20 years. The chassis is similar to that of the SA-6 but carries four missiles on a turntable that can be traversed through 360°. A second vehicle based on a similar chassis carries acquisition, guidance and tracking radars that provide information on the target's height, bearing and range. The missile, according to American sources, is about 5 m (16 ft 5 in) long and has a maximum effective altitude of 14000 m (45,930 ft) and a minimum altitude of less than 100 m (330 ft). Minimum range is about 3 km (1.86 miles) and maximum range is around 30 km (18.6 miles). Unconfirmed reports have stated that the SA-11 was introduced into the Soviet army in limited numbers in 1980 and that a small quantity have been deployed to Iraq and Syria for evaluation purposes.

USSR

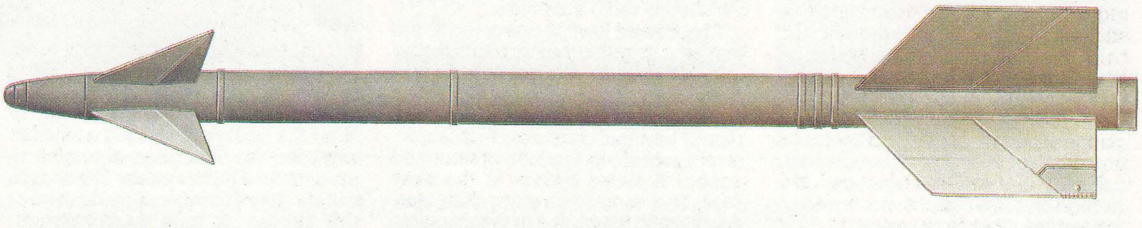
SA-13 surface-to-air missile system

The **SA-13** (an American designation in the absence of any known Soviet designation) was developed in the late 1970s and was first seen in the Group of Soviet Forces Germany (GSFG) in the spring of 1980. It is the replacement for the SA-9 Gaskin system on the BRDM-2 (4×4) chassis, and is issued on the scale of 16 systems per tank and motorized rifle division. Early in 1983 several SA-13 SAM systems were seen deployed around Kabul airport in Afghanistan.

The SA-13 is based on the chassis of the MT-LB multi-purpose tracked vehicle and has four missiles in the ready-to-launch position. The missiles are in containers of a type similar to those of the SA-9, and a version with six launch containers has also been observed. Between the two banks of two missiles is a range-only radar, though passive radar emission detectors are also mounted. Most sources state that the seeker on the missile is cryogenically cooled and operates on two frequency bands. The latter factor gives a higher degree of resistance to infra-red countermeasures such as flares dropped or ejected from aircraft and helicopters. Effective engagement altitude are a minimum of 50 m (165 ft) and a maximum of 10000 m (32,810 ft), and a slant range of 8 km (5 miles) is claimed. As far as it is known the SA-13 has no rapid reload system, although there is sufficient space inside of the vehicle to carry at least one complete reload of missiles. The system is believed to be in service with Syria.

USA

M48 Chaparral surface-to-air missile system



The **M48 Chaparral** low-level self-propelled SAM system was developed some 20 years ago to meet a urgent US Army requirement. It consists essentially of a modified M548 tracked carrier, which is a member of the M113 family, with a missile launch station mounted on the rear. The latter consists of the base structure and turret with its four Chaparral missiles in the ready-to-launch position. The Chaparral is basically the Sidewinder air-to-air infra-red homing missile modified for the surface-to-air role. In the US Army a composite anti-aircraft battalion has 24 Chaparral SAM systems and 24 M163 20-mm Vulcan self-propelled anti-aircraft gun systems, early warning for the battalion being provided by a number of truck-mounted AN/MPQ-49 Forward Area Alerting Radars.

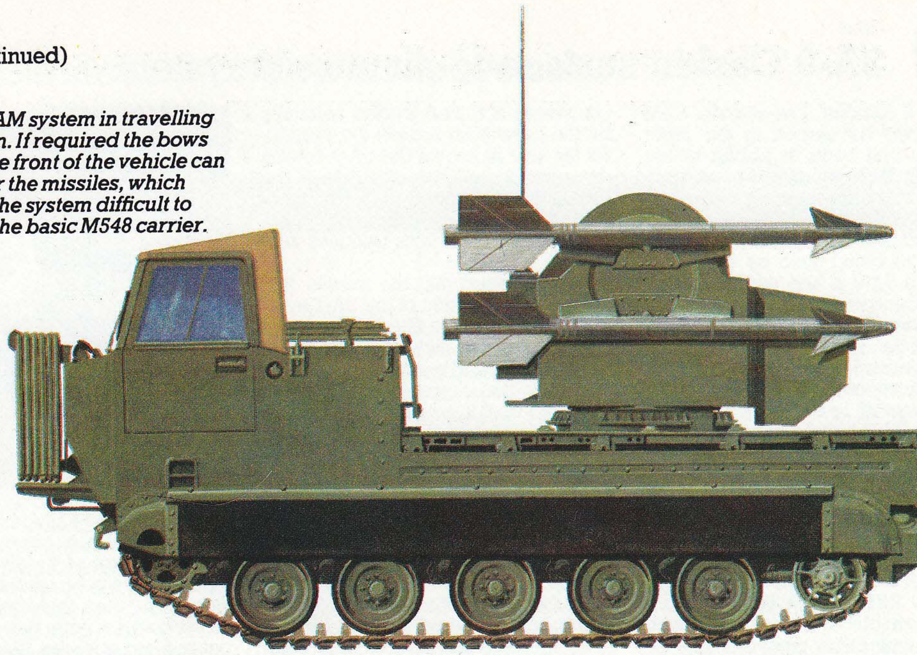
The original missile used with the system was the **MIM-72A** which weighed 85 kg (187 lb) of which 11.2 kg (24.7 lb) was explosive; this was replaced in production in the late 1970s by the much-improved MIM-72C which is slightly heavier at 86.3 kg (190 lb) but has a more powerful HE blast fragmentation warhead, new proximity fuse and a new seeker.

When travelling the launcher is normally covered by a tarpaulin cover over metal frames, which can quickly be removed and stowed at the front of the vehicle. Reserve missiles are carried below and to each side of the launcher, and are reloaded manually.

The basic Chaparral is a day system, and a typical target engagement would take place as follows. The target aircraft would first be detected visually or by the AN/MPQ-49 radar. The gunner, who is seated under a transparent dome in the centre of the launcher, with two missiles to each side of his position, then acquires the target and continues tracking it using his power controls. Turret traverse is 360°, and the missiles on their launcher arms can be elevated to +90° and depressed to −5°. When the target is within the infra-red sensing range of the missile an audio tone is given in the gunner's headset. The missile is then launched and the gunner can then start tracking another target or keep tracking the original target in case the missile does not hit the target. Once the missile is launched it homes onto the hot exhaust of the target and the proximity fuse means that a direct hit is not required in order to destroy the target. The Chaparral system can engage targets flying at an altitude of between 350 and 3050 m (1,000 and 10,000 ft) and has a maximum range of 6000 m (6,560 yards).

The Chaparral was to have been replaced in the US Army by the Roland surface-to-air missile system manufactured in the United States by Boeing and Hughes Aircraft, but production of the Roland system was terminated in 1983 after only 27 systems, these being issued to the Texas National Guard. To keep the Chaparral system effective into the 1980s and beyond, several improvements are already being carried out to the system. These include a new smokeless motor for the missile, which makes detection of the launcher itself more difficult; a new seeker to reduce the effect of enemy countermeasures; and a forward-looking infra-red thermal imaging device. The latter will be mounted on the forward part of the launcher and will give the system a partial night and adverse-weather capability as well as improving its performance under normal operating conditions.

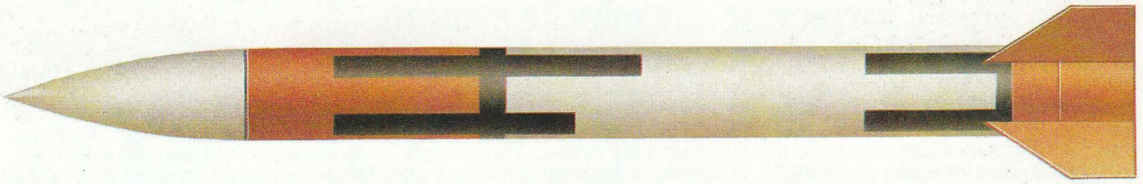
Almost 700 of these systems have now been built by Ford Aerospace, and in addition to being used by the US Army they are also operated by Ecuador, Greece, Israel, Morocco, Taiwan and Tunisia; a naval version has also been developed and is used by Taiwan.


Chaparral SAM system in travelling configuration. If required the bows stowed on the front of the vehicle can be fitted over the missiles, which then makes the system difficult to detect from the basic M548 carrier.

Specification
M48 Chaparral
Dimensions: length 2.91 m (9.54 ft); diameter 13 cm (5.12 in); span 64 cm (25.19 in)
Launch weight: 84 kg (185.18 lb)
Performance: speed, supersonic; range 6 km (3.72 miles); minimum engagement height 350 m (1,150 ft); maximum ceiling 3050 m (10,000 ft)

USA

MIM-104 Patriot surface-to-air missile system



The **MIM-104 Patriot** tactical air-defence system has been developed from 1965 to meet the requirements of the US Army for a missile system to replace both the HAWK and Nike-Hercules. Prime contractor is the Raytheon Corporation, the principal sub-contractors being Martin-Marietta Aerospace for the missile airframe and launcher, and the Hazeltine Corporation for the IFF interrogator. First test launches took place in 1970 but for a variety of reasons, including both cost and design problems, limited production of the system was not authorized for some time, and the first operational Patriot battalion was not fielded until early 1983.

A typical Patriot fire unit consists of the radar set, engagement control system, electric powerplant, five launch stations (although a maximum of eight can be controlled by one radar set and engagement set), and supporting vehicles and equipment.

The AN/MPQ-53 radar set is a multi-function phased-array unit that provides for all of the functions of airspace surveillance, target detection and track, and support of missile guidance. The combination of computer control and phased-array technology permits the time-sharing of functions so that the performance workload of this radar is equal to that of the nine different radars used by present-day systems. The radar is on semi-trailer that is towed by a standard 5-ton (6×6) truck.

The AN/MSQ-104 engagement station is installed in a container carried on the rear of a standard M816 (6×6) long wheelbase truck, and houses the system's two operators, the weapons control computer and two tactical display consoles. The software-controlled computer exercizes authority over all tactical operations from radar scheduling, weapon assignment, missile launch and intercept assessment. Several operating modes are available, including computer-aided manual mode, semi-automatic and full automatic, with the operator always retaining full override capability of computer decisions.

The M901 launch station is mounted on a semi-trailer which has its own generator and is also towed by a 5-ton 6×5 truck. Each of the four missiles is sealed into a canister which serves both as travelling and launcher tube. In a tactical situation the launchers are widely dispersed and communicate with the engagement control station via secure radio data links.

The missile itself is delivered to the unit as a certified round requiring no maintenance in the field. From the nose, the missile consists of the radome, semi-active radar (plus command) terminal guidance, high explosive warhead, propulsion system and control actuator section at the very rear. The missile has a five-year storage life and according to the manufacturer its high-g tail control outmanoeuvres any manned aircraft. The missile is powered by a single-stage solid-propellant Thiokol TX-486 motor which gives a maximum speed of Mach 3.

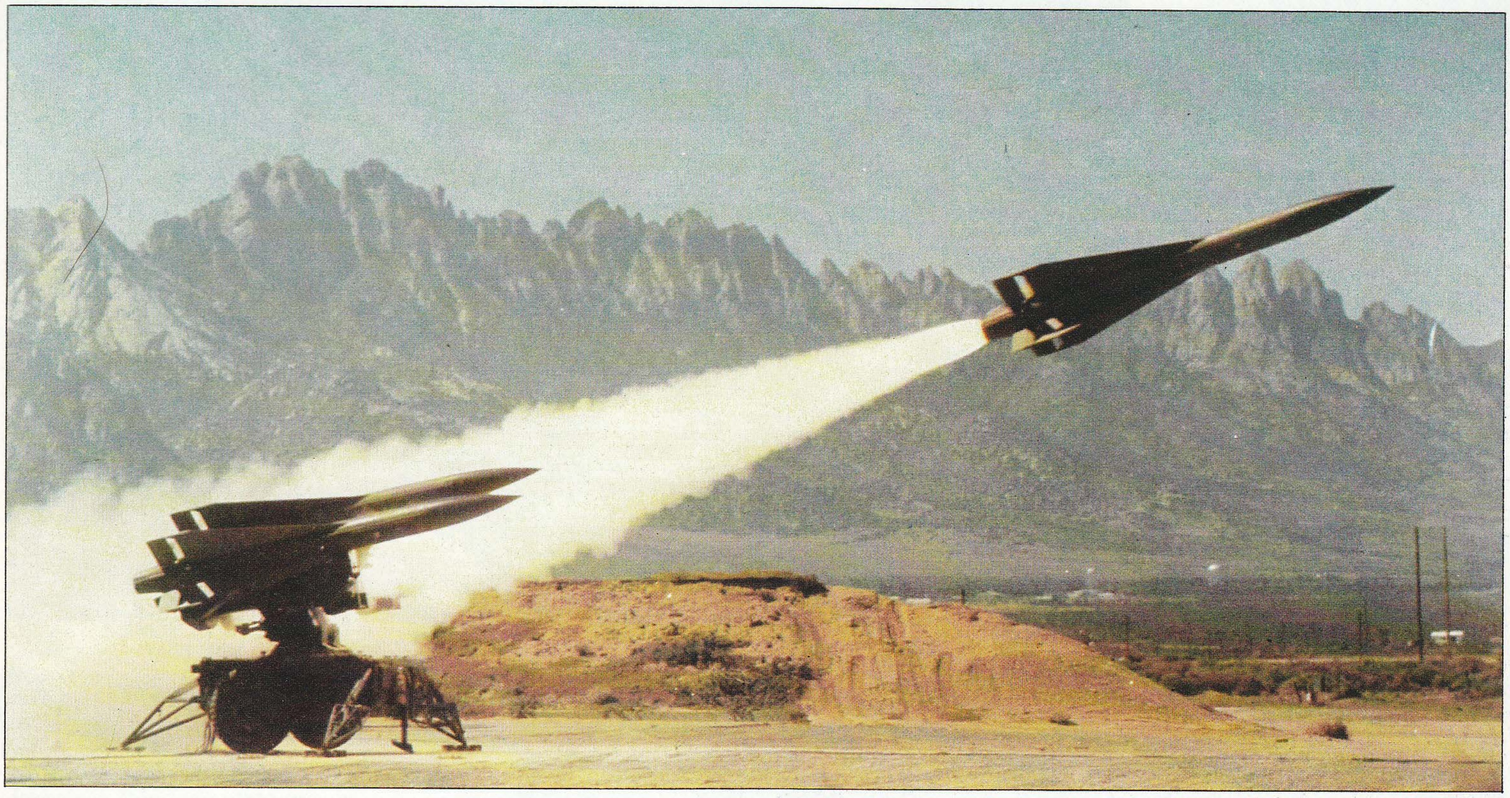
In 1979 the USA together with Belgium, Denmark, France, Germany, Greece and the Netherlands signed a memorandum of understanding to study the most practical and economic ways for the European countries to procure the Patriot system. The system will be fully operational by the end of the 1980s, its high performance, powerful warhead and unique Track Via Missile (TVM, with a data downlink to upgrade the information in the digital computer in the engagement control station) guidance aspect ensuring the ability of the US Army to deal with targets of an air-breathing nature at all altitudes.

A Patriot SAM is launched from its canister during early trials. In the US Army this SAM will replace the HAWK and Nike Hercules and is expected to be made under licence in Europe.

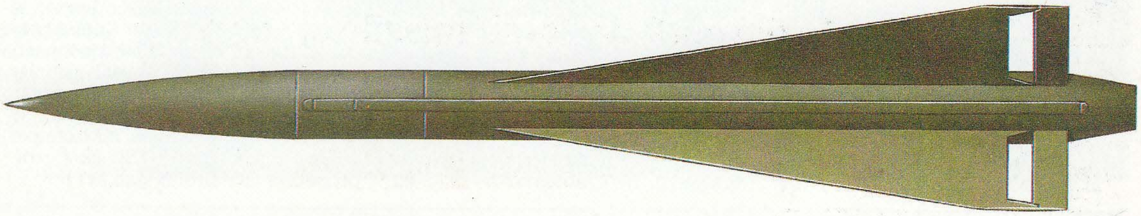
Specification
MIM-104 Patriot
Dimensions: length 5.18 m (17 ft 0 in); diameter 40.6 cm (16 in); wing span 91.4 cm (36 in)
Launch weight: about 998 kg (2,200 lb)
Performance: maximum ceiling 24000 m (78,750 ft); range 60 km (37.3 miles)

USA

MIM-23B Improved HAWK surface-to-air missile system



***Above:* Raytheon HAWK missile being launched. The HAWK is the most widely used SAM in the West and is also being built under licence by a European consortium headed by France and West Germany. Since being introduced in 1960 it has been constantly updated to enable it to remain an effective weapon system. The latest model is called the Improved HAWK.**



The **HAWK** (Homing All the Way Killer) was developed by Raytheon to meet the requirements of the US Army. The first guided launch took place in June 1956 when a HAWK successfully shot down a QF-80 drone aircraft. The first US Army **MIM-23A HAWK** battalion was activated in August 1960, and since then the type has been purchased by some 20 countries and is also being built under licence in Europe and Japan. Since it was first introduced the HAWK has been constantly updated to meet the changing threat. The type was first used operationally in the 1973 Middle East war when Israeli HAWKs were credited with the destruction of at least 20 Egyptian and Syrian aircraft.

The latest model is the **MIM-23B Improved Hawk**, and this has a new guidance package, a larger and more effective warhead, improved motor propellant, and many smaller changes to the fire-control system. Maintenance has also been much improved as electronics have not only become much smaller but also much more reliable since the missile was developed in the 1950s. The Improved HAWK entered service with the US Army in the 1970s, and most HAWK users are now bringing their older systems up to the improved standard.

Today an Improved HAWK battery consists of the Pulse Acquisition Radar, a new Continuous-Wave Acquisition Radar, the Range Only Radar, the Battery Control Centre, the high-power Continuous-Wave Illuminator, three launchers each with three missiles, plus tracked missile loaders/transporters. The launchers are mounted on a two-wheeled carriage that can be towed by a 2½-ton (6×6) truck or similar vehicles. A self-propelled version of the HAWK mounted on a modified M548 tracked carrier chassis designated the **M727 SP HAWK** was developed, but this was only used by Israel and the United States, and is no longer in service with the former.

A typical Improved HAWK target engagement takes place as follows. The PAR and CWAR (the latter concerned with low-altitude threats) sweep the HAWK battery's area of defence, and when a target is detected and confirmed as hostile its position is relayed to the CWI radar. The latter illuminates the target with electromagnetic energy which is reflected back to the guidance system of the missile. The HAWK missile tracks the target by following the reflected electromagnetic energy. The missile itself is fitted with a high explosive blast-fragmentation warhead, and is powered by a dual-thrust solid-propellant motor.

A recent introduction into the US Army MIM-23B force is the Northrop-developed Tracking Adjunct System (TAS). This is a passive sensor system which tracks targets picked up by the Improved HAWK radar and displays them on a television monitor. This increases the survivability of the HAWK battery as it enables operations to be carried out with a reduction of signals detectable by an enemy. It also permits the operator to discriminate between targets close together or near the horizon.

The nearest Soviet system to the Improved HAWK is the SA-6 'Gainful'; this is more mobile than the American system but it has a shorter operational range. In the US Army HAWK is to be replaced by the Raytheon Patriot.

Specification

MIM-23B Improved HAWK

Dimensions: length 5.12 m (16 ft 9½ in); diameter 35.6 cm (14 in); wing span 1.22 m (48 in)

Launch weight: 626 kg (1,380 lb)

Performance: effective ceiling 30 to 11580 m (100 to over 38,000 ft); range 40 km (25 miles)

USA

FIM-92A Stinger man-portable surface-to-air missile system

The **Stinger** man-portable surface-to-air missile system, officially designated **FIM-92A**, was developed to meet the requirements of the US Army and US Marine Corps by the Pomona Division of General Dynamics, who had developed the earlier Redeye. Main improvements over the Redeye may be summarized as an all-aspect engagement capability (it being possible for the operator to engage the aircraft while it is flying towards him), an IFF system, improved range and manoeuvrability, and much improved resistance to enemy countermeasures. The Stinger can intercept and destroy hovering helicopters and high-speed manoeuvring targets. It became operational with the US Army in Germany during 1981, and with the 82nd Airborne Division in the continental USA during 1982. It has also been ordered by Japan and will be built under licence in Europe.

A typical target engagement takes place as follows. The operator visually acquires the target and aligns this with the open sight on the launcher. He then

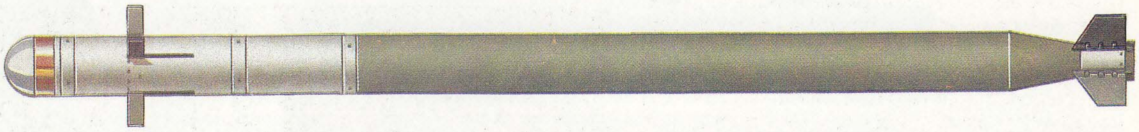
General Dynamics (Pomona Division) Stinger missile just coming out of its launcher tube. In September 1983 it was announced that this missile would be manufactured under licence in Europe for some NATO countries. A limited number of Stingers were used operationally by the SAS during the Falklands conflict; the missile is credited with destroying one Pucará ground-attack aircraft.

uses his belt-mounted IFF system, which is claimed to be the smallest of its type in the world, to identify the aircraft positively. If it is confirmed as hostile he actuates the missile functions and the missile is then launched and homes onto the enemy aircraft without any further action by the operator. The gripstock is then detached from the empty launcher, which is discarded to permit a fresh launcher/missile to be attached to the gripstock for the engagement of another target.

The missile has an HE warhead, electronic control system and a dual-thrust rocket motor, in which an ejector motor launches the missile before the flight motor boosts the missile to its Mach 2+ cruising speed once clear of the launcher. The Stinger uses a passive infra-red seeker and proportional navigation guidance.

For ease of transport the missile (in its launcher complete with gripstock, IFF system and battery coolant units) comes in a compact aluminium container which can be easily transported on the back of vehicles or in aircraft and helicopters without damage to the contents.

Currently under development by General Dynamics is the **Stinger-POST** (Passive Optical Seeker Technique) which has an advanced electro-optical seeker that uses a rosette scan to enable the missile to discriminate between targets and their background; this will be of particular use when engaging aircraft at very low level.



In addition to the air-defence version of Stinger two other versions have been proposed by General Dynamics. These are the **Multi-purpose Lightweight Missile System** (MLMS) and the **Air-Defence Suppression Missile** (ADSM), both of which are intended for use in helicopters. The MLMS would give helicopters an air-to-air capability against other helicopters, and a typical installation would consist of a pod of two missiles for the air-to-air role on one side of the helicopter and a pod of anti-tank missiles on the other side of the helicopter. As an alternative a small number of Stinger-armed helicopters would be dedicated to the air-to-air role. The ADSM would be similar to the Stinger but would be fitted with an anti-radiation seeker to enable it to home onto enemy radars, for example those of the 23-mm ZSU-23-4 self-propelled anti-aircraft gun system.

Specification

FIM-92A Stinger

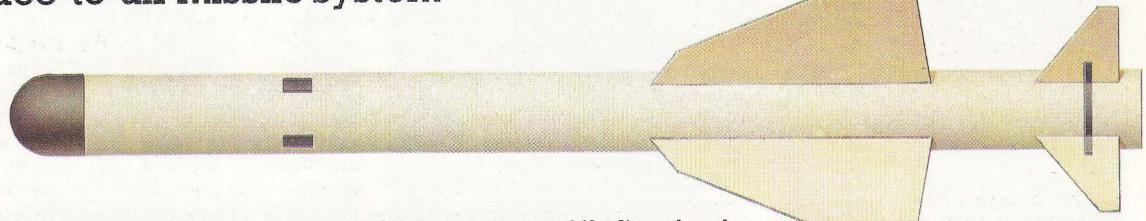
Dimensions: length 1.52 m (5 ft 0 in); diameter 7.0 cm (2.75 in); span 9.14 cm (3.16 in)

Weights: missile 10.1 kg (22.3 lb); missile and launcher 13.6 kg (30 lb); complete system 15.1 kg (33.3 lb)

Performance: maximum ceiling 4800 m (15,750 ft); maximum range 5 km (3.1 miles)

JAPAN

Tan-SAM surface-to-air missile system



Tan-SAM is transported and launched from an unarmoured (6×6) truck and entered service with the Japanese Ground Self-Defense Forces in 1982.

The **Tan-SAM** short range surface-to-air missile system has been developed by Toshiba from the mid-1960s as a replacement for the wide range of anti-aircraft guns at present used by the Japanese Ground Self-Defense Force, most of which date back to World War II. As a result of the usual shortage of funds, development of the Tan-SAM has been very slow, technical tests being carried out between 1972 and 1977 and operational tests in 1978 and 1979. Late in 1980 the weapon was finally standardized as the **Type 81** short-range SAM system, the first production units being delivered in 1982.

In the Japanese Ground Self-Defense Force the Tan-SAM will be deployed at division level, with each division allocated four sets, each of the latter comprising one fire-control vehicle and two launchers each mounted on an unarmoured Type 73 Truck (6×6), a type widely used by the Japanese Ground Self-Defense Force. The system will also be deployed by the Japanese Air Self-Defense Force for the defence of air bases.

The three main components of the system are the missile, the launcher and the fire-control system. The missile is powered by a single-stage solid-propellant rocket motor, which accelerates it to a maximum speed of about Mach 2.4. A major drawback is that the rocket emits a considerable amount of smoke, which could lead to the launcher being detected and subsequently destroyed. The missile has an HE warhead and an infra-red passive homing/inflight lock-on guidance system; and in the centre of the missile are four wings, the four control fins being located at the rear.

The launcher is mounted on the rear of the Type 73 truck and once the four missiles have been launched new missiles are loaded hydraulically, although they have to be unpacked from the transit cases by hand. The launcher is stabilized by hydraulically operated legs.

The fire-control system consists of a phased-array search radar and a fire-control computer plus three cathode-ray tubes (CRTs) on which target information is displayed. The radar antenna rotates 10 times per minute and sweeps through 360° in azimuth and 15° in elevation. In the sector-search mode it sweeps 110° in azimuth and 20° in elevation. The radar, which has an IFF system, has a range of 30 km (18.6 miles) and can handle a number of targets at the same time. The fire-control system has a four-man crew consisting of the commander, radar operator and two launch operators. To the rear of the cab is a generator.

Once the vehicles have halted it takes about 30 minutes for the system to become operational as the two launch vehicles have to be connected with the FCS; the vehicles can be up to 1000 m (1,095 yards) apart. Once operational the radar starts to search for targets with information (range, altitude and bearings) displayed on the CRT. The target is then selected by the commander and tracked by the radar. When the target is within range a missile is launched. For the first part of its flight the missile flies under command of the autopilot, but then the infra-red seeker takes over and locks onto the target and the target is destroyed. A Tan-SAM battery can handle up to four targets at once.

One of the major drawbacks of this system is the poor mobility of the Type 73 truck, the complete lack of any armour protection for the system and its crew, and the relatively low rate of fire.

Specification

Tan-SAM surface-to-air missile system

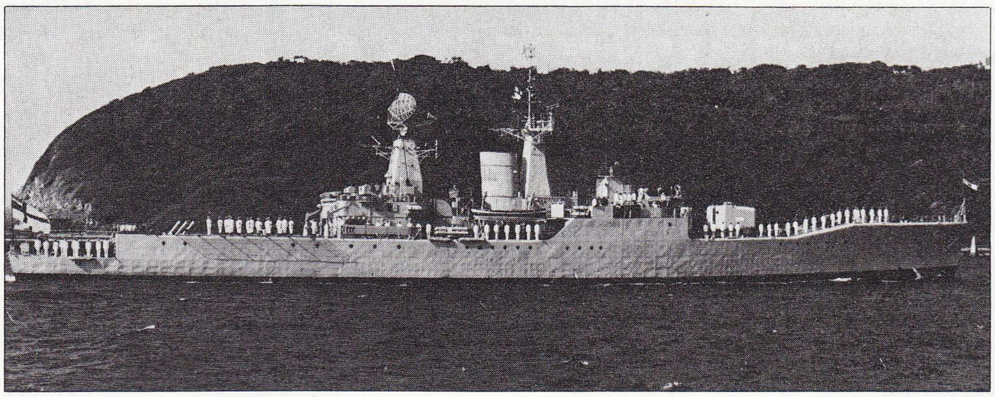
Dimensions: length 2.70 m (8 ft 10.3 in); diameter 16.0 cm (6.3 in); span 60.0 cm (23.6 in)

Launch weight: 100 kg (220 lb)

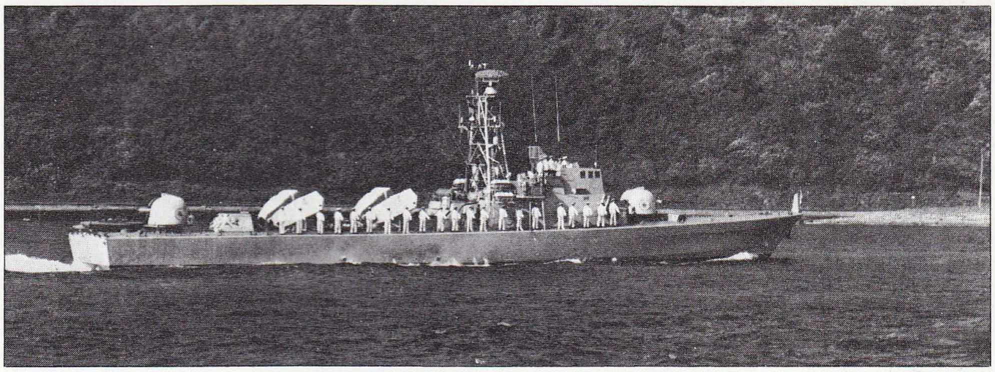
Performance: maximum ceiling (estimated) 3000 m (3,280 yards); maximum range (estimated) 7000 m (7,655 yards)

Armed Forces of the World

South Africa Part 3



Above: Basically a British Type 12 frigate, the 'President'-class President Kruger *is the largest fighting vessel in the South African Navy, but is now virtually obsolete.*



Below: A 'Minister'-class (basically the Israeli 'Reshef' design) fast attack craft. Armed with Skorpioen (Israeli Gabriel) anti-ship missiles, they give the South African Navy real punch in its coastal defence role.

The South African Navy

The South African Navy, once modelled on the Royal Navy, has been completely transformed in recent years. Today the emphasis is on defence of South African waters, with no intention of maintaining a general escort capability in conjunction with other Western navies.

This change of emphasis has been forced on the SAN by the international embargo on the supply of military equipment and the international 'cold shoulder'. With no encouragement from Europe or the United States to keep the sea lanes around the Cape of Good Hope clear for Western shipping, it is hardly surprising that South Africa has concentrated its naval efforts on self-defence. Personnel strength is about 6,750, found from volunteers and 24-month conscripts.

The main offensive strength consists of three French-built 'Daphne'-class submarines, 870-tonners of the locally-designated 'Maria van Riebeeck' class armed with 12 533-mm (21-in) torpedo-tubes. Hopes of acquiring two more modern 'Agosta'-class 1400-ton ships were dashed in 1978, when France belatedly enforced a United Nations embargo and refused to deliver them. The dockyard at Simonstown may yet undertake the construction of submarines, according to official sources, but this could not be done without considerable technical assistance. One likely source would be Argentina, which will have an advanced submarine-building facility within a few years.

Two ageing British-built 'Rothesay'-class frigates, locally designated 'President' class, are the only survivors of the anti-submarine force which existed a few years ago. They have been modernized with French radar and Italian fire-control systems, but they will not be replaced.

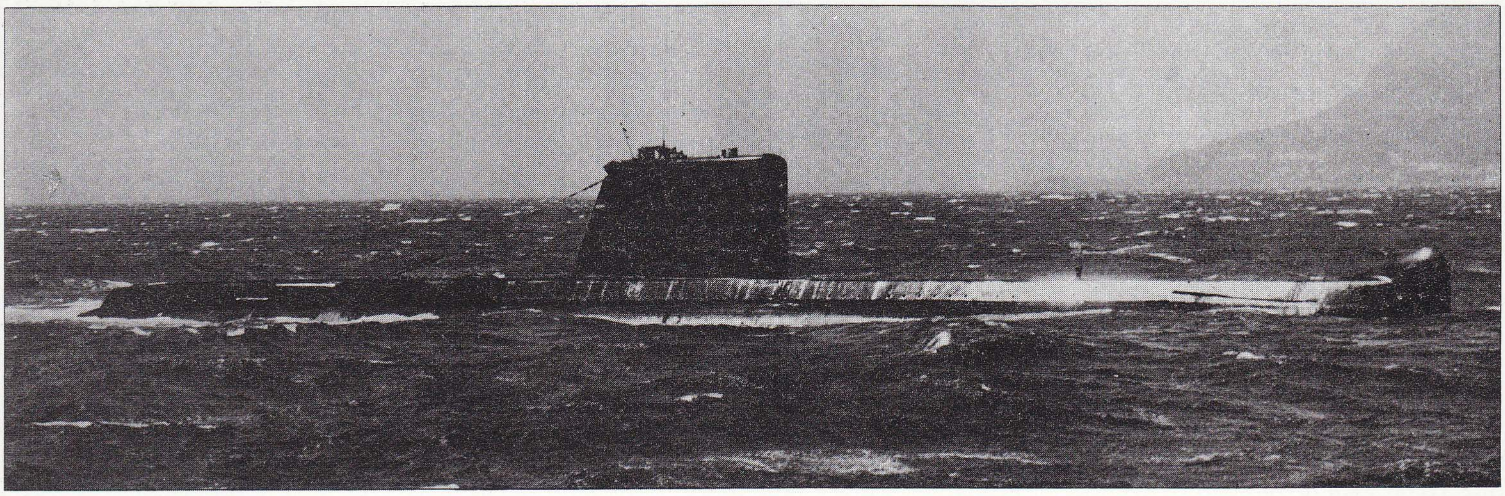
The most modern units are eight 62.2-m (204-ft) missile-armed patrol boats known as the 'Minister' class. Modelled on the Israeli 'Reshef' type, the first three were built at Haifa but the remainder have been built under Israeli supervision at Sandock Austral's yard in Durban. Like the Israeli boats they are armed with the Italian OTO-Melara 76-mm (3-in) gun and Italian radars, and their Skorpioen missiles (six to each boat) are a variant of the Israeli Gabriel 2, with locally made components. A further four are in various stages of construction at Durban, and to maintain them the SAN has built a special support complex.

Some locally-built patrol craft are used for inshore work, mainly with a view to replacing elderly British-built seaward defence boats. The minesweeping force comprises 10 'Ton'-class coastal sweepers built in the 1950s, and two of them have been converted locally to minehunters.

The remainder of the force is made up of auxiliaries, the largest of which are the fleet replenishment ship *Tafelberg* (a converted oil tanker) and the modern survey ship *Protea*. There are 30 small harbour patrol craft, a torpedo recovery vessel, a number of air-sea rescue craft, four tugs and an Antarctic supply ship. Local industry is clearly capable of providing ships up to a certain size, but there are not signs of further expansion into major warships.

South African Navy order of battle

six fast attack craft with Skorpioen missiles (a further six on order)
one anti-submarine frigate with one Wasp helicopter
three patrol submarines
seven large patrol craft
six minesweepers
two mine-hunters
one fleet supply ship



Emily Hobhouse*, a French-built 'Daphne'-class submarine, is one of three in the South African Navy. This class provides a large part of the Republic's offensive sea power.*